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Improving the environmental footprint of energy systems: Resource classification and management

Specifications for the application of the United Nations Framework Classification for Resources to Bioenergy Resources

Submitted by the Bioenergy Sub-group of the Expert Group on Resource Classification

Summary

This document provides the specifications for the application of the United Nations Framework Classification for Resources (UNFC) incorporating Specifications for its application to Bioenergy Resources. The intended use of this document is in conjunction with UNFC and the Specifications for the Application of UNFC to Renewable Energy Resources (Renewables Specifications). The Renewables Specifications represent rules of application of UNFC to Renewable Energy Resources, while this document represents rules of application of UNFC to Bioenergy Resources via the Renewables Specifications. Growing awareness and interest in renewable energy resources, including Bioenergy Resources, has highlighted a need to normalize the way in which renewable energy potential is reported. It is hoped that the inclusion of bioenergy specifications within UNFC will facilitate the appreciation of the potential role that bioenergy specifically, and renewable energy in general, must play as part of the larger energy sector.

This document has been reviewed by the Expert Group on Resource Classification at its eighth session in April 2017. Following review, the Expert Group recommended that the Specifications be submitted to the Committee on Sustainable Energy at its twenty-sixth session for endorsement.

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Preface

At the sixth session of the Expert Group on Resource Classification in April 2015, the Working Group on Application of the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 (UNFC-2009)[1] incorporating Specifications for its Application (as set out in United Nations Economic Commission for Europe (ECE) Energy Series No. 42, ECE/ENERGY/94) to Renewable Energy was asked to prepare draft commodity-specific specifications for bioenergy for review at the eighth session in April 2017. This request built on a previous advice at the fifth session in April 2014 to prepare a draft geothermal specification for review in 2016, which was subsequently approved.

To this end, the Working Group established the Bioenergy Sub-group, which is comprised of those members of the Renewable Working Group with relevant bioenergy expertise and additional experts from the sector.

Growing awareness and interest in renewable energy resources, including bioenergy, has highlighted a need to normalize the way in which renewable energy potential is reported. The renewable energy industry has become a fully commercialised sector, in which several major oil and gas companies have already started to play a significant role. These players have voiced a need for a common platform in which to assess and compare the potential of their renewable and non-renewable energy portfolios. A shared framework to evaluate renewable and non-renewable energy resources would also provide a foundation for investors, regulators, governments, and consumers to review current and future energy sustainability scenarios at the *Project*, company, country, region or global level. It is hoped that the inclusion of bioenergy within UNFC-2009 will facilitate the appreciation of the potential role that bioenergy specifically, and renewable energy in general, must play as part of the larger energy sector.

[1] The United Nations Framework Classification for Resources (UNFC) changed its name in April 2017. Prior to this, UNFC was known as the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 (UNFC-2009). UNFC-2009 is used throughout this document to maintain consistency with the previous documents.

Acknowledgments

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Further acknowledgements go to the Technical Advisory Group of the Expert Group on Resource Classification and to Alistair Jones and James Ross for their input in addressing technical issues that emerged during the work of the Working Group. The Bioenergy Sub-group also wishes to recognize the work and support of the Geothermal Sub-group, which prepared the Geothermal Specification that helped to guide the development of the Bioenergy Specification, and directly supported the efforts of the Bioenergy Sub-group as well as the efforts of Gail Werren as technical editor for the document.

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I. Introduction

1. The purpose of this document is to enable the application of the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 (UNFC-2009)[2] as well as the Specifications for the application of the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 to Renewable Energy Resources (Renewable Energy Specification),[3] as set out in ECE Energy Series No. 42, ECE/ENERGY/94, to *Bioenergy Resources*.

2. The intended use of this document is in conjunction with UNFC-2009 and the Renewable Energy Specifications.

3. The Renewable Energy Specification represents rules of application of UNFC-2009 that are to be applied to all Renewable Energy Resources, while this document represents rules of application of both UNFC-2009 and the Renewable Energy Specification to *Bioenergy Resources*. Hence, this document is to be used only in conjunction with the two documents mentioned above, and not as a stand-alone document. Text that has been kept unaltered from UNFC-2009 incorporating Specifications for its Application is indicated in this document via underlined text and text that has been kept unaltered from the Renewable Energy Specifications is indicated in this document via highlighted text as specified in the key below for clarity. In addition, defined terms are indicated as such by the use of capitals and italic text, e.g., *Bioenergy Source*.

Text Highlighting Key

Text as per the Renewable Energy Specifications

Text as per the UNFC-2009

II. Bioenergy definitions

A. Bioenergy Sources and Resource Definition

1. Bioenergy Source Definition

4. According to the *Renewable Energy Source* definition presented in the Renewable Energy Specification,[4] the *Renewable Energy Source* for bioenergy, the *Bioenergy Source*, is specified as **"the biomass source, and/or the biogenic fraction of an energy source that is available for the conversion into Energy Products."**

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[2] (2013) *United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 incorporating Specifications for its Application, ECE Energy Series No. 42*, United Nations Economic Commission for Europe, United Nations Publication Sales No. 14.II.E.4, ISBN 978-92-1-117073-3, eISBN 978-92-1-0506516-5, ISSN 1014-7225, Geneva, Switzerland and New York, United States of America.

[3] (2016) Specifications for the application of the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 to Renewable Energy Resources, United Nations Economic Commission for Europe, Task Force on Application of UNFC-2009 to Renewable Energy Resources, Geneva, Switzerland

[4] Part II.A, Renewable Energy Specification.

5. Consistent with the definition of Renewable Energy used in the Renewable Energy Specification,[5] the rate at which the biomass is extracted from the biomass deposit (*Renewable Energy Source*) shall not exceed the replenishment[6] rate of the *Renewable Energy Source*. In the majority of cases, the rate of replenishment will be dependent on human activity and/or intervention—for example, farming, forestry management, etc.—and the replenishment rate may be determined to be greater than the naturally occurring replenishment rate provided the cost of the fertilizer, water, and or other inputs is accounted for on the E axis.

6. Under this specification, not all biomass deposits are *Renewable Energy Sources*. For example, a dead forest that is no longer growing is not renewable unless the *Project* includes some sort of replanting so that the biomass can replenish itself. Furthermore, it is assumed that the biomass deposit is replenished with biomass that is useable by the *Project* and in substantially the same form as the extracted biomass. For example, a hardwood forest cannot be considered a *Renewable Energy Source* if the trees consumed by the *Project* are replaced with grasses. For the avoidance of doubt, the bio-fraction of wastes and residues that occur as a by-product of human activity can also be considered as *Bioenergy Sources*, provided the production is equal to or greater than consumption, is predictable, and is expected to continue over time.

7. It is the responsibility of the UNFC Evaluator to determine at what rate biomass can be extracted without impacting the *Renewable Energy Source*; biomass extracted in excess of the replenishment rate shall not be considered a *Renewable Energy Source* under this specification.

8. In addition to an assessment of the renewable nature of the *Bioenergy Source*, it is recognized that, in many cases, actual rates of replenishment and long-term viability of a biomass resource may depend on a range of factors such as water availability, soil condition, weather and climate, disease, and pathogen risks. When evaluating a *Project* as part of the G axis evaluation (Part III Section C), it is important to consider these factors, ranges of uncertainty around each factor, and their impact on the *Renewable Energy Source*.

9. It is equally recognized that, in many jurisdictions, certain regulatory conditions and standards will exist that constrain the manner in which the *Bioenergy Source*/biomass can be accessed. This will include land use regulations and zoning, water permitting and abstraction rights, farming or forestry standards, land set-aside requirements, sustainability standards, regulations pertaining to the definition of wastes and residues, and regulatory recognition under renewable energy standards, among others. The influence of these elements on a specific *Project's* viability shall be considered as part of the evaluation of the E axis (Part III Section A).

2. Bioenergy Energy Product Definition

10. The Specifications for the application of the UNFC-2009 to Renewable Energy Resources[7] define an *Energy Product* as being **"directly linked to (or a direct replacement of) a fungible energy commodity and is saleable in an established market"**.

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[5] Part I. Introduction, Renewable Energy Specification.

[6] Replenishment in the context of a renewable *Bioenergy Source* is taken to include the renewal of material for subsequent harvesting and/or collection through such activities as the planting, cultivation and other management practices for crops / biomass, and the generation and collection of waste and/or residues from agricultural, industrial and other activities and/or processes.

[7] Part II.A, Renewable Energy Specifications.

11. Given the broad scope of the Bioenergy Sector, which covers many different energy pathways that sometimes include intermediate processing steps and a broad range of fuel types, this definition has been refined and clarified for the purposes of the Bioenergy Specification.

12. Moreover, for the purposes of the UNFC Bioenergy Specification, the *Energy Product* definition is further refined to include the products itemized in List A, provided they are derived from renewable *Bioenergy Sources*.

List A: Predefined Energy Products for the Purposes of the UNFC Bioenergy Specification

(a) Electricity;

(b) Heat (e.g., steam);

(c) Hydrocarbon gases (e.g., methane, propane, etc.);

(d) Alcohols (e.g., ethanol, butanol);

(e) Fatty acid methyl ester (FAME);

(f) Synthetic liquid hydrocarbons produced from biomass, including hydrotreated vegetable oil (HVO), Fischer-Tropsch diesel (BTL), and other liquid hydrocarbons.

13. In addition to List A, a Project may identify another resource as an *Energy Product* for the purposes of the Bioenergy Specification provided it meets the *Energy Product* definition in the Renewable Energy Specification and all of the following criteria:

(i) It is a fungible and tradable commodity;

(ii) It has a clear energy-related market value, as evidenced by market quotations, and/or price indexes;

(iii) Its predominant[a] global use is for energy.

14. These additional criteria have been introduced to recognize the broad scope of the Bioenergy Sector, the likelihood of technological and market development, and the UNFC-2009 Framework principle-based approach. List A is intentionally non-exclusive to allow some scope for *Energy Products* to be determined on a *Project*-specific basis. For example, in certain circumstances, wood pellets may fulfil the *Energy Product* criteria. Likewise, this consideration might be extended to torrefied wood pellets, pyrolysis oils, and certain vegetable oils grown only for energy applications (e.g., *jatropha curcas* oil), if or when clear and fungible markets develop for such products.

15. In the circumstances that a *Project* defines an *Energy Product* that is not included in List A, supporting rationale and evidence shall be provided that demonstrates fulfilment of the *Energy Product* requirements in the overarching Renewable Energy Specification and the three additional criteria. In addition, the evaluation shall ensure that it complies with the requirements in the Specification in terms of the avoidance of double counting (see Part III Section G), the measurement units that are used for the resource quantification, and any subsequent conversion to other measurement units (see Part III Section H).

[a] The specification intentionally does not define predominant nor set a threshold value, preferring to allow specification users to establish practice. However, users may wish to consider the share of petroleum crude oil, natural gas, and coal that go for energy use versus their total consumption.

16. In the circumstances where a *Project* involves a combination of renewable and non-renewable feeds, only the production associated with the renewable proportion will be considered as an *Energy Product* for the purposes of the UNFC Bioenergy specification.

17. In addition to these definitions, the choice of *Energy Products* needs to be consistent with the definition of the *Project* and the definition of the *Project's Reference Point*(s) (see Part II Section B).

18. In terms of providing additional clarifications, the following (non-exhaustive) list (List B) of bioenergy feedstocks and co-products that may be considered to be Bioenergy Sources as per the definition in Part II Section A.1, but shall not be considered to be Energy Products, as they fail to meet one or more of the defining criteria. This does not preclude their use as Bioenergy Sources to produce Energy Products as defined in list A that can be classified under this Specification.

List B: Bioenergy feedstocks and co-products that may be considered to be Bioenergy Sources, but not as Energy Products for the Purposes of the UNFC Bioenergy Specification.

(a) Grains (e.g., maize, wheat, rice, barley, triticale), and their associated non-energy conversion co-products, including starch streams, isoglucose, and protein products (e.g., distillers grains);

(b) Sugar crops (e.g., sugarcane, sugarbeet);

(c) Raw sugar, refined sugar, and molasses whether derived from lignocellulosic or conventional sugar feedstocks;

(d) Oilseed crops (e.g., palm oil fruit, soybean, rapeseed/canola, sunflower, cotton, coconut);

(e) Unprocessed forestry and arboricultural biomass

(f) Agricultural wastes and process residues (e.g. corn stover and cobs, cereal straws, sugarcane bagasse & straw, husks, pips, nutshells, palm tree empty fruit bunches, etc.);

(g) Industrial by-products (e.g. sawdust, fruit and vegetable residues, cardboard, demolition timber etc.);

(h) Animal wastes and residues;

(i) Bio-fraction of municipal solid wastes.

3. Renewable Bioenergy Resource Definition

19. Per the Renewable Energy Specifications[2] *Renewable Bioenergy Resources* are the cumulative quantities of *Energy Products* produced or converted from the renewable *Bioenergy Source*, measured at the *Reference Point*.

4. Treatment of Non-Energy Products

20. In many cases, a *Bioenergy Project* will also have associated production of non-energy co-products and/or wastes or residues (e.g., sugar, molasses, protein products, starch streams, fiber residues). The economic value accruing to the *Project* as a result of such production may be considered within the assessment of the *Project's* economic viability; however, per the *Energy Product* definition, such production shall not be considered in the resource assessment. The exception is those *Projects* to convert, upgrade, or otherwise to alter the production process to increase the production of *Energy Products* as an alternative

to the non-energy product production may be considered as resources dependent on the *Project's* maturity.

B. Project and Reference Point Definition

21. The resource classification process consists of identifying a *Project*, or *Projects*, associated with a Renewable *Bioenergy Source*, estimating the regenerative potential of Renewable Bioenergy available, estimating that portion of those available quantities that can be extracted as Energy Products by each *Project*, and classifying the *Project(s)* based on *Project* (technical) status and feasibility and on economic and social viability.

22. The *Project* is the link between the Renewable *Bioenergy Source* and sales quantities of *Energy Products* and provides the basis for economic evaluation and decision-making. There is a clear recognition of risk versus reward for the investor, linked to uncertainties and/or variability in the *Renewable Energy Source*, the efficiency of the extraction process, energy product prices and market conditions (including policy support mechanisms) and social acceptability. In the early stages of evaluation, the *Project* might be defined only in conceptual terms, whereas more mature *Projects* will be defined in significant detail.

23. The cumulative quantity of *Energy Products* taken to the *Project's* economic, contractual, or other time limit defines the Renewable *Bioenergy Resource* quantity.

24. A *Project* shall define the *Reference Point* as the point at which the cumulative quantities of *Energy Products* are measured or estimated, and the quality of the *Energy Product* is in compliance with the appropriate specification.

25. The *Reference Point* will typically be either the point of sale to third parties where measurement using appropriately calibrated custody transfer metrology equipment occurs or where custody is transferred to an entity's downstream (or distribution) operations. The specific custody transfer point will depend on the legal structure and contract terms of the specific *Project* being evaluated. In circumstances where the classification is being carried out a country or regional level, or being conducted for non-disclosure purposes, it may be appropriate to define the reference point consistent with the reporting point for the relevant energy statistical data or other relevant statistical data. It may be desirable to make the estimation coherent with the methodology in the relevant statistical dataset, both in terms of units of measurement and relevant quality parameters.

26. Where market, sales, regulatory, and/or quality specifications[9] exist relevant to the *Energy Product(s)*, the *Energy Products* concerned and the associated estimation of the cumulative quantities shall be in compliance and consistent with those specifications. The *Reference Point(s)* and associated specifications shall be disclosed in conjunction with the reported quantities.

[9] We note that a number of international and national specifications may be applicable including, but not limited to, the International Organization for Standardization (ISO), European Committee for Standardization (CEN), ASTM International (ASTM), the GB standards issued by the Standardization Administration of China, SAE, formerly the Society of Automotive Engineers, and GOST maintained by the Euro-Asian Council for Standardization, Metrology and Certification.

C. Project Lifetime/Limit

27. The forecasted *Bioenergy Resources* for a *Project* are constrained by the economic limit or lifetime of the *Project*. Entitlement defines the quantities that accrue to project participants. The economic limit is defined as the cumulative production of *Energy Product(s)* beyond which the remaining cumulative net operating cash flows from the *Project* are negative, a point in time that defines the *Project's* economic life. A significant difference with non-renewable energy *Projects* is that the economic limit will often not be an appropriate basis for the resource assessment because renewable energy is normally replenished at an equal or higher rate than consumed, and other *Project* limitations may become relevant before the economic limit is reached.

28. Generally, it will be necessary to limit the resources to a defined *Project* lifetime of a number of years. This *Project* lifetime can be determined from the design basis of the facilities or key components of those facilities, or based on industry practice or benchmarks for similar *Projects*.

29. Routine maintenance requirements do not constrain the *Project* lifetime, but a need for significant capital re-investment, requiring a new *Project* investment decision and/or regulatory approval, would have to be captured, from a resource assessment perspective, as a separate *Project* of lower maturity.

30. The reporting entity's entitlement (see Part II Section D) to the Renewable Energy Resources may also be limited in time and, if of lesser duration than the design life of the facilities, will be the constraining factor for the entity's resource reporting.

D. Access to Source

31. Consistent with the Specifications for the application of the UNFC-2009 to *Renewable Energy Resources*,[10] a classifying entity needs to consider the degree of access the project has to the *Bioenergy Source*, both in terms of quantities available and the level of confidence in accessing those quantities.

32. When using the Specifications for disclosure purposes, the classifying entity shall demonstrate that it has sufficient entitlement to the *Bioenergy Source*. For *Bioenergy Projects*, this typically refers to the biomass feedstock that is subsequently converted by the *Project* into the final *Energy Product(s)*. A list of business and/or contractual models that are typically used in the Bioenergy Sector to access its biomass feedstock is provided in Table 1. In addition, the assessment of entitlement shall consider the following aspects:

Table 1
Non-exhaustive list of Business and Contractual Models typically used in the Bioenergy sector to access biomass

Business Contractual Model	*Brief Description*
Equity Producer	Entity owns the land and directly, or via the contracted services of a third party, cultivates and harvests the biomass produced.
Land Lease	Entity leases the land and directly, or via contracted services with the landowner or third parties, cultivates and harvests the biomass produced.
Partnership	Entity enters a contractual partnership with the landowner, where for a

[10] Part II. D Entitlement: Renewable Energy Specifications.

Business Contractual Model	*Brief Description*
	stipulated period of time, the Entity or a contracted third party acting on its behalf cultivates and harvests the biomass. In return, the landowner is remunerated based on a certain percentage value of the biomass harvested as stipulated in the terms of the contract.
Stumpage	A contract typically used in the forestry sector where the classifying entity has the right (or, depending on contract terms, an obligation) to harvest timber from a given land base. The fee can be based on per tree harvested, or per stump, or based on a standard measurement of the timber/wood recovered.
Waste Collection Permit/Contract	The right to collect the waste or residue from a defined area; e.g., the collection of municipal solid waste or a waste/residue from an industrial process or operation.
Agriculture or Forestry Residue Collection Contracts	The right (or potentially obligation) to recover or collect a certain quantity or percentage of residue from a defined area of land or operation, typically used to secure supplies of forestry residues, such as tree crowns, thinnings, understory, or small roundwood. Also can be used to secure supplies of crop residues such as corn stover. The contractual term can be single harvest/year or multi-harvest/year.
Purchase Agreement	Can either be a long-term (covering multiple deliveries) or a spot (single delivery) purchase of a biomass provided that such contracts are adequate to reasonably secure regular supply for the relevant *Bioenergy Project*. Typically, spot contracts might be relevant for commoditized biomass sources within fungible, freely traded markets, e.g., grains, oilseed crops.

(a) The legal and/or contractual terms and conditions relating to the biomass entitlement, which *are in place at the time of the assessment*, will form an important (but not sole) determinant of the entitlement assessment. Specific elements will be the duration of the agreement and its implication for the quantities of biomass; commercial aspects such as pricing, delivery incentives/penalties, business continuity provisions, and relevant quality parameters; and the stipulations concerning the termination, extension and renewal of the agreement.

(b) The purchaser shall receive full title to the biomass, and be subject to the price and conversion risks while the biomass and/or resulting energy products remain in the custody of the purchaser. Tolling agreements or other service structures where the conversion and price risks are borne by others shall not be considered as demonstrating entitlement.

(c) Sufficient entitlement can be considered to be in place beyond the duration of existing arrangements; for example, considering the option of lease extensions and/or renewals or for new agreements. However, the assessment shall consider the certainty of any extension and provide the supporting evidence.

(d) Purchase agreements, both long-term and spot, shall be considered as demonstrating sufficient entitlement for *Bioenergy Sources*; however, the following aspects shall be considered:

(i) For the avoidance of doubt, this excludes purchase agreements of *Energy Products*, which do not demonstrate sufficient access or entitlement upon which to carry out a resource classification under this specification.

(ii) The quantities of the *Bioenergy Source*/Biomass directly contracted for in the purchase agreement(s) that is/are in place at the time of the assessment, shall

typically be considered as the quantities with the highest confidence (G1) while quantities to be purchased under spot or other contracts after the time of the assessment may be included as part of the best estimate (G1+G2).

(iii) Consideration may also be made to quantities outside of those directed to be contracted in the purchase agreement(s); for example, considering the extension, rollover, or replication of the purchase agreement(s). Such an assessment must consider:

- The degree of confidence in the extension/rollover, etc. For example, this could include the classifying entity's capacity and capability in securing sufficient quantities over the period in question for the *Project*. This assessment can be made in light of the entity's track record with this or similar *Projects*.
- The type and nature of the purchase agreement is consistent with those agreements typically used for the market and commodity concerned and is adequate to reasonably secure supply. For example, in non-fungible markets, which typically would require multi-year purchase agreements in order to ensure supplies on a long-term basis, the extension of a spot purchase agreement would not be considered appropriate.
- Any requirements necessary in order to secure financing for the *Project*.
- The availability of analytical data regarding the current and projected future biomass stocking levels and production capabilities within a reasonable distance of the *Project's* location, taking into account such factors as historical and projected biomass production rates; the degree of infrastructure to access, cultivate, harvest, transport, and replenish the biomass stocks; and biophysical risks that may adversely impact biomass availability (e.g., storms, fires, pests, diseases).

(iv) The price and/or margin risk shall be considered both in the assessment of economic viability of the resource (E axis) and the quantities under the G axis in terms of the implications for unit operating margins and the ability to maintain throughputs. This assessment can be based either on historic margins and/or future market assessments (where they exist). A *Project* that comprises part of a market/sector that has track record of lower utilisation rate/economic run cuts due to low or negative margins, will need to ensure that this is appropriately considered in the assessment.

33. Where the classification is being carried out for purposes other than for disclosure, the requirements regarding the assessment of entitlement in paragraph 32 above need not apply. Nonetheless the classifying entity shall still consider the degree of access the project has to the Bioenergy Source, both in terms of quantities available and the level of confidence in accessing those quantities.

E. Access to Market

34. Consistent with the Specifications for the application of the UNFC-2009 to Renewable Energy Resources[3], a classifying entity must demonstrate that it has:

(a) Sufficient access and entitlement both to the conversion/processing asset to convert the *Bioenergy Source* to the *Energy Product(s)*; and

(b) The opportunity for reward through the subsequent sales of the *Energy Product(s)*; and

(c) Sufficient infrastructure and/or logistics with sufficient capacity to transport or otherwise transfer the production to the necessary markets and/or end users for sale either exists or is planned.

35. Table 2 presents the typical business/contractual models that are used in the Bioenergy Sector to access the conversion/processing of the biomass to *Energy Products*.

Table 2
Non-exhaustive list of Business and Contractual Models typically used in the Bioenergy sector to access biomass conversion/processing

Business/Contractual Model	*Brief Description*
100% Equity Owner	Entity has 100% equity ownership of conversion/processing asset(s) and is the operator, or subcontracts wholly or partially operations to a third party.
Operated Joint Venture	Conversion asset(s) is held within a Joint Venture, where the classifying entity is the operator of the asset(s).
Non-Operated Joint Venture (non-consolidated)	Conversion asset(s) is held within a Joint Venture, where the Joint Venture is the operator. None of the joint venture shareholders has operatorship.
Non-Operated Joint Venture (minority shareholder)	Conversion asset(s) is held within a Joint Venture, where the classifying entity is a minority shareholder and operatorship is either held by the Joint Venture or another shareholder/partner.
Toll Manufacturing	Processing of an entity's *Bioenergy Source* (biomass) is carried out by a third party (owner of conversion asset[s]) in return for a toll manufacturing fee.

36. Irrespective of the Business/Contractual model employed, the following principles shall be used to demonstrate the classifying entity has sufficient access and entitlement to the conversion/processing step(s).

(a) The classifying entity has exposure to conversion/processing risks, such as, exposure to yield, throughput, and downtime risks.

(b) The classifying entity has exposure to operating cost risks.

(c) The classifying entity has ownership or title to the *Energy Products'* output at the *Project*-defined *Reference Point*.

37. The following principles shall be used to demonstrate that the classifying entity has sufficient opportunity for reward through the subsequent sales of the *Energy Product(s)*.

(a) The classifying entity has ownership or title to the *Energy Products'* output at the *Project*-defined *Reference Point*.

(b) The classifying entity is exposed to the commercialization and price risks associated with the regulatory compliance, marketing, and sales of the *Energy Product(s)*.[11]

(c) Commercial arrangements are consistent with typical contractual arrangements for the *Energy Product* and sector in question, and there are reasonable expectations that the *Energy Product* can be monetized. For example, Power Purchase Agreements (PPA) exist in those markets where a spot power market is either limited or does not exist.

[11] When the classification is being carried out for disclosure purposes, *Energy Products* sold at zero or negative value due to storage limitations or other curtailment restrictions should not be included in the estimated quantities of a *Project* – see Part III Section A: E axis.

38. When the specification is being used for the purposes of disclosure, and in jurisdictions where regulators set more specific guidance regarding entitlement and commercial criteria, those criteria shall supersede the above requirements.

F. Intermittent or Variable Production

39. Many *Bioenergy Projects* involve planned or expected intermittent or variable production. This variability can be due to a multitude of factors and occur over a range of time spans or frequencies, for example, diurnal due to variations in operational efficiency, seasonal due to processing campaigns associated with harvests, and perennial due to biomass yield variation from one harvest to the next.

40. Ultimately, an estimate of a *Bioenergy Project's* resources will typically require the preparation of a future production forecast/scenario(s) of the associated energy products. Any intermittency/variability shall be appropriately considered within that assessment. This will most typically occur under the G axis. Assumptions that impact overall estimate of cumulative production of *Energy Projects* must be made explicit, reconciled to the appropriate G axis confidence limits, and supported by an appropriate evidence base. Relevant examples would be estimates of biomass yields, assumptions on processing campaign durations, conversion unit throughputs, and yields.

41. If there are reasonable expectations due to the intermittent or variable nature of production, or if there will be a proportion of *Energy Products* that either cannot be sold or would be sold at a zero or negative price, then this shall be appropriately factored into the assessment of the economic viability of the *Project*. In addition, when the classification is being carried out for disclosure purposes the estimated quantities of the *Energy Products* impacted cannot be included as resources (see Part III Section A E axis).

42. Receding or halted production due to a force majeure event (e.g., crop failure, fire, extreme weather, unforeseen operational issues), should not generally be considered in the production forecast. However, if such an event does occur, the *Project* classification shall be reviewed in light of that event and the potential future implications. An example of this would be the time and actions required to remediate/restore a biomass crop following a significant crop failure.

G. Projects with Multiple Resource Types

43. Some *Bioenergy Projects* will involve the production of two or more types of *Energy Products* (e.g., ethanol, heat, and electricity from a sugarcane ethanol mill). In such circumstances, per UNFC-2009 Part IV.D, estimated quantities should be reported separately for each commodity or significant product type that will be sold, used, transferred or disposed of separately. Where estimates for different commodities or product types have been aggregated for reporting purposes, and separate estimates are not provided, the aggregated estimates shall be accompanied by a statement clarifying which commodities or product types have been aggregated and identifying the conversion factor(s) used to render them equivalent for the purposes of aggregation.

H. National Resource Classifying

44. Evaluators are referred to the specifications in the UNFC-2009 Part IV. National Resource Reporting.

III. Definitions of classes, categories and supporting explanations

45. As set out in the generic specifications the UNFC-2009 is a generic principle-based system in which quantities are classified on the basis of three fundamental criteria: economic and social viability (E); field *Project* status and feasibility (F); and geological knowledge and the level of confidence in the potential recoverability of the quantities (G); using a numerical coding system. Combinations of these criteria create a three-dimensional system. Categories (e.g., E1, E2, E3) and, in some cases, sub-categories (e.g., E1.1) are defined for each of the three criteria as presented and defined in Annexes I and II of the Generic Specifications. The UNFC-2009 subclasses are defined in order to provide additional clarity and granularity in using the UNFC-2009 framework; however, their use is optional.

46. Additional requirements and explanations are provided below for the application of the UNFC-2009 to *Bioenergy Resources*.

A. E-axis Categories - Establishing Socio-Economic Viability

47. The first set of categories (the E axis) designates the degree of favourability of social and economic conditions in establishing the commercial viability of the *Project*, including consideration of market prices and relevant legal, regulatory, social, environmental, and contractual conditions.

48. In accordance with the definitions of E1, E2, and E3, economic assumptions shall be based on current market conditions and realistic assumptions of future market conditions. Except where constrained by regulation, assumptions of future market conditions should reflect the view of either: (1) the organization responsible for the evaluation; (2) the view of a competent person or independent evaluator; or, (3) an externally published independent view, which is considered to be a reasonable forecast of future market conditions. The basis for the assumptions (as opposed to the actual forecast) shall be disclosed.

49. Current market conditions and realistic assumptions of future market conditions should include policy support mechanisms for Renewable Energy, but shall not assume that such mechanisms will become more beneficial in the future unless already specified in the regulation.

1. Distinction between and considerations for E1, E2 and E3

50. The E axis encompasses all non-technical issues that could directly impact the viability of a *Project*, including commodity prices, operating costs, legal/fiscal framework, environmental regulations and known environmental or social impediments or barriers.

51. For the purposes of the Bioenergy Specification, these issues have been grouped into five criteria: Access and Entitlement, Market and Sales Connectivity, Authorisation, Economic Case Validation, and Social and Environmental Considerations. Additional requirements and information on these criteria are provided in the sections below, and their relevance in determining the appropriate E axis classification is set out in Part III Section A 7.

52. The distinction between quantities that are classified on the Economic axis as E1, E2, or E3 is based on the assessment of a *Project's* maturity against each of these five criteria and subsequently, their impact on the expectations on the *Project's* viability in terms of the economic access to the *Bioenergy Source* and its subsequent conversion to and sale of *Energy Products*.

53. Any one of these issues or criteria could prevent a new *Project* from proceeding (hence, quantities would be classified as E2 or E3, as appropriate), or it could lead to the

suspension or termination of activities in an existing operation. Where activities are suspended, but there are "reasonable prospects for economic extraction and sale in the foreseeable future;" remaining technically recoverable quantities shall be reclassified from E1 to E2. Where "reasonable prospects for economic extraction and sale in the foreseeable future" cannot be demonstrated, remaining quantities shall be reclassified from E1 to E3. For a *Project* to be classified as E1 or E2, the requirements in Table 3 shall be met in all five groups, i.e., Access and Entitlement, Market and Sales Connectivity, Authorisation, Economic Case Validation, and Social and Environmental Considerations, though the degree to which the requirements must be met differ between E1 and E2.

2. Definition of key E axis terms

54. In addition to the five criteria, there are three key terms that are integral to the E axis definition. These include:

55. **Reasonable Expectations:** This term is used within the E1 classification and concerns the likelihood of obtaining necessary regulatory approvals, permits and contracts necessary to implement the *Project*.

56. For the condition of *Reasonable Expectations* to apply in the case of governmental and other regulatory approvals and/or permits, the application or submission shall have been made to the authority in question, together with all the substantive supporting information. Aside from minor additional information requests or clarifications, the entity shall have specific justification to expect that the authority in question has all the necessary information to consider the application, that the application will be approved in line with the requirements of the *Project*, and will be approved within a period that is typical for applications of that type in the jurisdiction concerned. The condition of *Reasonable Expectations* can also apply in circumstances when the application is still to be made or to be fully completed. This is provided the entity has a demonstrated track record of obtaining approvals for the same or substantively similar applications under the same jurisdiction, there is no reason to expect that the application in question will not be similarly approved by the authority in question in line with the requirements of the *Project*, and the application will be approved within a period that is typical for such applications in the jurisdiction in question.

57. For the condition of *Reasonable Expectations* to apply to commercial/financing contracts or agreements, negotiations shall be underway, with the specific justification that agreement will be achieved within a time period that would be typical for such contracts or agreements and within any previously sanctioned boundary conditions (e.g., authority to negotiate). The conditions of *Reasonable Expectations* can also apply in the circumstance when negotiations have not commenced, provided that the entity has a demonstrated track record of negotiating similar contracts/agreements to like terms and conditions with the same counterparty(s).

58. If circumstances arise within the governmental/regulatory approvals or permitting process or within the negotiations around commercial contracts or agreements that indicate it is likely that any stipulated requirements or terms will have a material impact on the economic viability of the *Project*, the condition on *Reasonable Expectations* shall be considered not to be met, with the appropriate implications for the E axis categorization.

59. *Reasonable Time Frame:* This term concerns the time frame within which all approvals, permits and contracts necessary to implement the *Project* are to be obtained. This should be the time generally accepted as the typical period required to complete the task or activity under normal or typical circumstances within the region or jurisdiction concerned (for example, environmental permitting in a specific jurisdiction). Five years is recommended as a benchmark but a longer time frame could be applied where, for

example, the development of an otherwise economic project is deferred at the option of the owner for market-related reasons, or to meet contractual or strategic objectives, among other reasons. In these circumstances, the justification shall be provided.

60. *Foreseeable Future:* This term is used to distinguish between the E2 and E3 classifications as to the period of time that a *Project* can make a reasonable projection of the occurrence of future market conditions or events that determine the economic viability or other factors of a *Project*. For the purposes of the Bioenergy Specification, this would typically be five years, but may be extended where there is specific justification. For example, if a necessary condition or event necessary for economic viability is not projected to occur within five years, the *Project* is deemed not to be economically viable in the *Foreseeable Future*.

3. Access and Entitlement

61. Consideration of the Access and Entitlement Criterion shall consist of an assessment of a *Project's* maturity of the degree of access and entitlement to both the *Bioenergy Source* (e.g., the biomass feedstock) and the conversion asset or assets used to subsequently convert the *Bioenergy Source* into *Energy Product(s)* and any associated non-energy products. This assessment shall follow the requirements set out in Sections D and E of Part II of this specification, and the requirements set out in Table 3 ("Definition and Use of E-axis Categories and Sub-categories"), in terms of both the necessary conditions and evidence required to determine the appropriate E-axis classification.

4. Market Sales and Connectivity

62. Assessment of Market Sales and Connectivity shall be determined by the ability of the classifying party to monetize the *Project's Energy Products*. Per the Bioenergy specifications Section E, the classification decision will be based upon a review of items such as: infrastructure availability and capacity, off-take or sales agreements in place, and registration/qualification requirements completed.

63. The following principles shall be used to demonstrate that the reporting entity has sufficient opportunity for reward through the subsequent sales of the *Energy Product(s)*.

(a) That the reporting entity has ownership or title to the *Energy Products* output at the *Project* defined *Reference Point*.

(b) That the reporting entity is exposed to the commercialisation and price risks associated with the regulatory compliance, marketing, and sales of the *Energy Product(s)*.[12]

(c) Commercial arrangements are consistent with typical contractual arrangements for the *Energy Product* and sector in question, and that there are reasonable expectations that the *Energy Product* can be monetized. For example, this would include assurance that a PPA exists in those markets where a spot power market is either limited or does not exist.

64. Section E shall be used in conjunction with the table at Table 3 ("Definition and Use of E-axis Categories and Sub-categories") to determine the appropriate E-axis classification, and the necessary supporting evidence.

5. Authorisation

[12] Energy Products sold at zero or negative value due to storage limitations or other curtailment restrictions should not be included in the estimated quantities of a *Project* — see Part III Section A: E axis.

65. Consideration of a project's maturity in terms of Authorization shall include all the necessary regulatory and permitting approvals required by governments and/or relevant regulatory authorities. The degree of progress towards sanction and commitment of the entity implementing the *Project* by joint venture partners and/or by financial partners should be considered as part of the F assessment.

Examples of external approvals include:

(a) Government approval, planning approval/permitting

(b) Approval and/or compliance with any legislation or permitting required for the cultivation of biomass

(c) Water abstraction and disposal licences/permits, etc.

(d) Waste disposal permits

(e) Attainment of Technical Specifications (i.e., fuel specifications)

(f) Authorization and/or regulations pertaining to electric power grid connections

(g) Compliance with necessary regulations in order to access markets/monetize *Energy Product* (e.g., registration/recognition under specific regulations necessary to qualify for regulatory support, sustainability standards).

66. The table in Table 3 ("Definition and Use of E-axis Categories and Sub-categories") sets out the requirements and evidence base required for an appropriate E axis classification.

6. Economic Case Validation

6.1. Cash Flow Based Project Evaluation

67. Project evaluations are based on estimates of future production and the associated cash flow schedules for each development *Project*. The sum of the associated annual net cash flows yields the estimated future net revenue. When the cash flows are discounted according to a defined discount rate and time period, the summation of the discounted cash flows is termed net present value of the *Project*. The calculation shall reflect:

(a) The expected quantities of production projected over identified time periods.

(b) The estimated costs associated with the *Project* to develop and produce the quantities of production at its Reference Point, including environmental, abandonment, and reclamation costs charged to the *Project*, based on the evaluator's view of the costs expected to apply in future periods.

(c) The estimated revenues from the quantities of production based on the evaluator's view of the prices expected to apply to the respective commodities in future periods, including that portion of the costs and revenues accruing to the entity.

(d) Future projected production and revenue related taxes, royalties, and/or leasing charges expected to be paid by the entity.

(e) A *Project* life that is limited to the period of entitlement or reasonable expectation thereof.

(f) The application of an appropriate discount rate that reasonably reflects the weighted average cost of capital or the minimum acceptable rate of return applicable to the entity at the time of the evaluation.

68. While each organization may define specific investment criteria, a *Project* is generally considered to be "economic" if its "best estimate" or "most likely" case has a positive net present value under the organization's standard discount rate or at least has a positive undiscounted cash flow.

6.2 *Assumptions and Scenarios*

69. Evaluators shall clearly identify the assumptions on commercial conditions utilized in the evaluation and shall document the basis for these assumptions. The economic evaluation underlying the investment decision is based on the entity's reasonable forecast of future conditions, including costs and prices, which will exist during the life of the *Project* (forecast case). Such forecasts are based on projected changes to current conditions; current conditions are defined as the average of those existing during the previous 12 months. In case of *Projects* using long-term off-take agreements, the terms of the agreement will supersede current conditions and should be used in the economic evaluation.

70. Evaluations may be modified to accommodate criteria imposed by regulatory agencies regarding external disclosures. Alternative economic scenarios can be considered in the decision process and, in some cases, to supplement reporting requirements. For example, evaluators may examine a case in which current conditions are held constant (no inflation or deflation) throughout the *Project* life (constant case). These criteria may include a specific requirement that, if the production were confined to the technically Commercial Resources estimate, the constant case should still generate a positive cash flow. External reporting requirements may also specify alternative guidance on current conditions (for example, year-end costs and prices). There is no guideline requiring that *Project* financing be confirmed prior to classifying *Projects* as Commercial Resources, but this may be an external requirement in some other reporting methods. In many cases, loans are conditional upon the same criteria as above; that is, the *Project* shall be economic based on Commercial Resources only.

71. In general, if there is not a reasonable expectation that loans or other forms of financing can be arranged such that the development will be initiated within a reasonable time frame, then the *Project* should be classified as Potentially Commercial (E2). If financing is reasonably expected but not yet confirmed, the *Project* may be classified as Commercial, but no E1 may be reported.

6.3 *Treatment of Policy Support*

72. A variety of policy support mechanisms, regulatory instruments, and financial incentives (e.g., feed-in tariffs, premiums, tax credits) exist worldwide to reflect the value that various stakeholders place on renewable energy (or bioenergy specifically). Some policy support mechanisms may be available on a project-by-project basis, while others may be available to all such renewable/*Bioenergy Projects* in the market. In addition, renewable energy support mechanisms are typically phased out over time, or once the qualifying *Renewable Energy Sources* reach a certain size or share of overall energy production.

73. When considering the use of the sub-categories E1.1 and E1.2, policy support mechanisms for renewable energy may be included in the economic validation, with the type, value and duration disclosed. Policy support mechanisms shall not be assumed to become more beneficial in the future unless already so specified in the regulations.

7. Social and Environmental Considerations

74. Generally, social and environmental considerations are not resource specific. Each *Bioenergy Project* shall consider both social and environmental factors as part of its

classification. For further guidance, practitioners should refer to the document currently in development by the E-axis Subgroup of the Expert Group on Resource Classification: Draft guidance on accommodating environmental and social considerations in the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 (ECE/ENERGY/GE.3/2016/8).

Table 3
Definitions and Use of E-axis Categories and Sub-categories

Category	*Definition*	*Supporting Explanation (UNFC-2009, Part 1, Annex I)*	*Additional Bioenergy Context*	
E1	*Extraction and sale has been confirmed to be economically viable.*	*Extraction and sale is economic on the basis of current market conditions and realistic assumptions of future market conditions. All necessary approvals contracts have been confirmed or there are reasonable expectations that all such approvals contracts will be obtained within a reasonable time frame. Economic viability is not affected by short-term adverse market conditions provided that longer-term forecasts remain positive.*	*Criteria*	*Requirements*
			Access and Entitlement	Beneficial rights exist to access and exploit the *Bioenergy Source*, as well as rights to utilize a conversion process (via either an existing asset or an investment) to convert the *Bioenergy Source* into marketable *Energy Products*. The entity shall be exposed to risks and rewards associated with both the *Bioenergy Source* and the Conversion asset(s). A supply framework (see Part II Section D) for defined quantities of the *Bioenergy Source* for a determined time period is in place. If the supply framework is dependent on contractual agreements, these are signed and/or there are expectations that this will occur within a reasonable time frame. The time period for which rights exist should be defined; moreover, the contracts shall at least cover sufficient quantities to support the economic operation of the *Project*.
			Market and Sales Connectivity	Infrastructure with sufficient capacity to transport or otherwise transfer the production to the markets in question for sale either exists or is planned and approved for implementation. Any necessary off-take or sales agreements required to monetize the *Energy Products* and any associated non-*Energy Products* are in place, as evidenced by signed documents, for a determined time period or there are *Reasonable Expectations* that these will be secured within a *Reasonable Time Frame*. The *Project's Energy Product(s)* meet any relevant standards or specifications, and any necessary registration, approval, or qualification required for the *Energy Products* to be recognized under any relevant legislation is either in place, or there are *Reasonable Expectations* for this to occur within a *Reasonable Time Frame*.
			Authorisation	All necessary regulatory and permitting approvals required by governments and/or relevant regulatory authorities are either in place, supported by documentary evidence for a defined time period, or are expected to be in place within a *Reasonable Time Frame*.

Category	*Definition*	*Supporting Explanation (UNFC-2009, Part 1, Annex I)*	*Additional Bioenergy Context*	
			Economic Case Validation	An economic case exists that demonstrates the *Project* is economically viable, either as a new investment or as an existing operation. Consistency exists between capital investment, operating costs, and the expected production profile and *Project* lifetime. Economic indications demonstrate positive cash flows over the determined lifetime of the *Project*.
			Social and Environmental Considerations	Any social and environmental contingencies have been resolved, or there are *Reasonable Expectations* for them to be resolved within a *Reasonable Time Frame*. The *Project* is not expected to be halted or its operations seriously impeded due to a lack of social licence to operate.[13]

Sub-category	*Definition (UNFC-2009, Part 1, Annex II)*	*Additional Bioenergy Context*
E1.1	*Extraction and sale is economic on the basis of current market conditions and realistic assumptions of future market condition*	No additional clarifications.
E1.2	*Extraction and sale is not economic on the basis of current market conditions and realistic assumptions of future market condition, but is made viable through government subsidies and/or other consideration*	In addition to the overarching requirements for E1, the calculation of economic viability is dependent on regulatory support. This includes any regulatory support and/or grants or subsidies needed to make the current *Project* economically viable (see Part III Section A 6.3). If grants or subsidies were used in the past (e.g., to develop the technology or process) they are no longer relevant to the classification of the *Bioenergy Resource*.

[13] For further guidance refer to "Draft guidance on accommodating environmental and social considerations in the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009", April 2016.

Category	*Definition*	*Supporting Explanation (UNFC-2009, Part 1, Annex I)*	*Additional Bioenergy Context*	
E2	*Extraction and sale is expected to become economically viable in the Foreseeable Future*	*Extraction and sale has not yet been confirmed to be economic but, on the basis of realistic assumptions of future market conditions, there are reasonable prospects for economic extraction and sale in the Foreseeable Future*	*Criteria*	*Requirements*
			Access and Entitlement	Beneficial rights exists to access and exploit the *Bioenergy Source*, as well as either rights to utilize a conversion process (via either an existing asset or an investment) to convert the *Bioenergy Source* into marketable *Energy Products*. A supply framework (see Part II Section D) for defined quantities of the *Bioenergy Source* for a determined time period is not yet in place, but there are expectations that this will occur within *the Foreseeable Future*.
			Market and Sales Connectivity	The market(s) for the sale of the *Energy Product(s)* have been identified, and there are robust estimates or assumptions for the likely prices. At least one potentially viable means of transport or transfer of the product(s) to the market(s) has been identified. There is sufficient evidence to expect that any necessary off-take or sales agreements required to monetize the *Energy Products* and any associated non-*Energy Products* will be forthcoming within the *Foreseeable Future*. There is sufficient evidence to expect that the *Project's Energy Product(s)* will meet any relevant standards or specifications, and any necessary registration or approval required the *Energy Products* to be recognized under any relevant legislation within a *Reasonable Time Frame*.
			Authorisation	A development plan has been defined, and there is evidence to expect execution of all necessary regulatory and permitting approvals required by governments and/or relevant regulatory authorities within in the *Foreseeable Future*.
			Economic Case Validation	An economic case exists that demonstrates that the *Project* is economically viable on the basis of realistic assumptions of future market conditions. Consistency exists between capital investment, operating costs and the expected production profile and *Project* lifetime. Economic indications demonstrate positive cash flows over the determined lifetime of the *Project*.

Category	*Definition*	*Supporting Explanation (UNFC-2009, Part 1, Annex I)*	*Additional Bioenergy Context*	
			Social and Environmental Considerations	Social and environmental contingencies have been identified, and there is a defined plan to address and resolve those contingencies within the *Foreseeable Future*.[14]

No E2 sub-categories are defined.

Category	*Definition*	*Supporting Explanation (UNFC-2009, Part 1, Annex I)*	*Additional Bioenergy Context*	
E3	*Extraction and sale is not expected to become economically viable in the Foreseeable Future or evaluation is at too early a stage to determine economic viability.*	*On the basis of realistic assumptions of future market conditions, it is currently considered that there are no reasonable prospects for economic extraction and sale in the Foreseeable Future; or, economic viability of extraction cannot yet be determined due to insufficient information (e.g., during the assessment phase). Also included are quantities that are forecast to be converted, but which will not be available for sale.*	*Criteria*	*Requirements*
			Access and Entitlement	The *Bioenergy Source* has been identified, and a preliminary evaluation has occurred, but access has not been secured or confirmed. Likewise, a preliminary evaluation of the necessary conversion asset (existing or investment) has been made, but access is not secured or confirmed.
			Market and Sales Connectivity	Potential market(s) for the future sale of the *Energy Product(s)* and/or non-*Energy Products* have either not been identified or only indicative estimates on pricing and market volumes are available. There are plans for further evaluation to identify at least one commercially viable business case.
			Authorization	Ability to obtain necessary governmental and/or regulatory approvals and permits is unknown or deemed unlikely to occur within the *Foreseeable Future*.
			Economic Case Validation	The economic case/viability cannot be determined due to insufficient information; or, based on realistic assumptions of market conditions, the *Project* is not economically viable.
			Social and Environmental Considerations	Both social and environmental issues have not yet been identified or evaluated, or there are significant social and environmental contingencies that will halt or seriously impede the implementation of the *Project*, and there is either no clearly defined plan to resolve the issues, or resolution is unlikely to occur in the *Foreseeable Future*.

Sub-category	*Definition (UNFC-2009, Part 1, Annex II)*	*Additional Bioenergy Context*

[14] For further guidance refer to "Draft guidance on accommodating environmental and social considerations in the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009", April 2016

E3.1	*Quantities that are forecast to be extracted, but which will not be available for sale*	This includes energy extracted from the *Bioenergy Source* that is used internally by the conversion process to produce the *Energy Products* (e.g., power and steam generation for on-site use); therefore, not available for sale.
E3.2	*Economic viability of extraction cannot yet be determined due to insufficient information (e.g., during the exploration phase).*	No additional clarifications.
Sub-category	*Definition (UNFC-2009, Part 1, Annex II)*	*Additional Bioenergy Context*
E3.3	*On the basis of realistic assumptions of future market conditions, it is currently considered that there are not reasonable prospects for economic extraction and sale in the Foreseeable Future.*	No additional clarifications.

B. F-axis Categories — Establishing Field Project Status and Feasibility

75. The F axis designates the maturity of studies and commitments necessary to implement *Bioenergy Projects*. These extend from early exploration or evaluation of a *Bioenergy Resource* through to a *Project* that is extracting/producing and selling *Energy Product(s)*, and reflects standard value chain management principles. The assessment of maturity covers both the technical feasibility of the *Project* and the level of commitment by the *Project* sponsors to proceed with the *Project* and its maturation stages prior to operation.

76. In order to assign a *Bioenergy Resource* to any class, except for category F4, a development plan needs to be defined consisting of one or more *Projects*. The level of detail appropriate for such a plan may vary according to the maturity of the *Project* and may also be specified by regulation.

1. Distinctions between and considerations for F1, F2, F3

77. It is important to note that the F axis is intended to capture both the technical feasibility and the maturity of a *Project*, and in doing so, represents the level of risk in the technology as well as the level of commitment by the *Project* sponsor, the classifying entity, joint venture partners, and/or financial partners. Generally, F1 *Projects* do not require significant technical refinements prior to implementation and commitment of capital funds, or the *Project* sponsor does not require any further technical studies prior to the decision to commit capital. F2 *Projects* are still in the development process and require further technical definition prior to a decision to commit capital funds, while F3 *Projects* do not have sufficient information to quantify the quantity of *Energy Products* that may be extracted.

78. The feasibility analysis is to include, but may not be limited to, the availability and maturity of biomass (the *Bioenergy Source*), the maturity of the conversion technology used to produce the *Energy Product*, the extent to which the biomass growth characteristics can be quantified, and the degree of progress toward sanction by the sponsoring parties.

79. To be included in the Commercial *Project* class (F1), the *Project* may be in operation, approved for development, or at the stage in which sufficient information has been aggregated to confirm the feasibility of a fully defined *Project*. To be included within the Potential Commercial *Project*/Non-Commercial *Project* class (F2), studies are underway to evaluate the feasibility of the *Project*, and further development work is necessary on biomass availability, the conversion technology, and/or the offtake of the *Energy Product* in order to sufficiently define the *Project* for sanction. F2 includes *Projects* in which the development is pending, on hold, unclarified, or not viable given the current state of technology. *Exploratory Projects* (F3) are those *Projects* where insufficient information is available to evaluate the quantity of extractable renewable *Energy Products* that may be available, thus further study is necessary prior to development of the *Project*.

2. Treatment of Technology Developments

80. While there are many commercially available technologies in the Bioenergy sector, a number of emerging technologies are currently in development and/or deployment around the world. The state of development may be classified within the F axis based on the technology development and the degree to which a *Project* has been identified to utilize the technology. We note that the state of technology development should be considered a constraint upon the F axis classification, but it may not be the limiting constraint when an evaluator considers the feasibility of obtaining feedstock for the facility, the level of

commitment of the *Project* sponsor, and the feasibility of transporting the *Energy Products* to their respective markets.

81. Many Bioenergy conversion technologies have followed the technology development cycle outlined below in which the performance of the technology is demonstrated with a successively larger set of equipment and longer operating run times. From smallest to largest, the development cycle typically includes laboratory-scale, pilot-scale, demonstration-scale, pioneer-scale, and commercial facilities.

(a) *Laboratory-Scale:* Sometimes referred to as *bench-scale*, laboratory-scale operations are used to demonstrate the performance of single-unit operations within the conversion technology so that the technology developers can define the sequence of operations necessary to convert the biomass to an *Energy Product*. It is important to note that the scale of the unit operations is that required to generate meaningful data; large equipment does not necessarily imply that the facility is pilot-scale. *Projects* with laboratory-scale technologies would typically be considered F3 as there is insufficient information available to define the *Project* at the stage of technology development.

(b) *Pilot- and Demonstration-Scale:* Pilot-scale facilities are used to demonstrate the chemistry and yield of the integrated unit operations of the technology while demonstration-scale facilities are used to estimate the availability of pioneer facilities, refine the anticipated maintenance requirements, and may provide an intermediate scale such that engineers can scale up the technology from pilot-scale to pioneer-scale. *Projects* with pilot- and demonstration-scale technologies could be considered F2, and Evaluators may utilize different F2 subclasses according to the level of work performed and the commitment level of the developer.

Integrated pilot-scale systems are necessary to determine the system-wide impact of changes to individual unit operations and the impact of recycle streams planned for the future commercial facilities. Many technology developers use these systems to optimize the processing conditions and/or determine the boundary conditions in which the process must be operated to prevent upsets. While generally much larger than pilot-scale facilities, demonstration-scale facilities are not intended to be commercially viable but rather provide an interim scale to mitigate risk in the scale-up of individual unit operations, collect additional data to assist with long-term operations and maintenance planning, and estimate the availability of the future commercial facility. Availability is typically presented as the percentage of time that a system is available to produce the products on an annual basis; the balance of the year is lost to planned or unplanned facility outages.

(c) *Pioneer-Scale:* These first-of-a-kind facilities are designed to be commercially viable, with revenues from the sale of products capable of supporting the operational and debt costs imposed on the *Project*. Pioneer-scale facilities demonstrate the soundness of the technology, but the technology is typically not considered to be proven until the facility has achieved multiple years of stable operations or successive facilities have been constructed and are in operation. Pioneer-scale facilities for which capital has been committed and implementation is underway could be considered to be F1.2, while pioneer-scale facilities whose feasibility has been demonstrated but capital has not been committed could be considered to be F1.3. Pioneer-scale facilities that have completed their ramp-up to full capacity and have multiple years of stable operations may be considered F1.1.

(d) *Commercially Available Technologies:* These facilities have an operating history and/or a number of commercial analogues from which an Evaluator can establish the technical performance of the facilities in a commercial environment. We note that the reference commercial facilities should use technology from the same technology developer; a technology developer's first facility should not be considered commercial regardless of

the number of similar facilities in service. From a technology perspective, a commercially available technology would typically be considered F1; however, in this case, the degree of sanction becomes the governing constraint. *Projects* using a commercially available technology and for which capital has been committed could be considered F1.2, while *Projects* whose feasibility has been established but capital not committed would typically be considered to be F1.3.

82. In certain cases, the technology and or processes to grow and or aggregate new or previously uncollected biomass types are still in development. In such situations, Evaluators should consider the extent to which further development is required prior to operations and should adjust the *Project* classification to F2 or F3 as necessary.

(a) *Greenhouse Data, Small Plots, and Indirect Estimates:* Agronomic data based on plant performance in greenhouses, single-year small plot or strip trials, and indirect estimates based on the performance of surrogate species is typically not considered to be sufficient to determine the feasibility of a *Project*; subsequently, *Projects* with biomass production estimates at this stage would be considered to be F3.

(b) *Single-Year Large Plots, Multiple-Year Small Plot, and Currently Cropped Related Species:* Agronomic data based on a single year of a large plot (greater than 1 hectare), small plot data obtained over multiple years of testing, and data from related species grown in the target area is typically considered to be sufficient to define a *Project* but further work is necessary to establish the feasibility of utilizing the biomass crop in question. Due to the need for additional work, *Projects* with this maturity would typically be considered as F2.

(c) *Multiple-Year Large Plots, Currently Intercropped Species, and Historical Plot Data in Location:* Multiple-year large plot (greater than 1 hectare) testing in multiple locations, estimates based on intercropped species such as corn and soybeans, or multiple years of crop data in the *Project* location are considered to be sufficiently detailed to support an F1 designation.

83. An estimate for the F1 category and/or its sub-category shall be based on established operational data both for the *Bioenergy Source* and the conversion process(es). For the *Bioenergy Source*, this will form established operational data (e.g., yield, and relevant quality parameters) from commercially available biomass, or from biomass that is at the multiple-year large plot stage of development, and/or data based on intercropped species. Similarly, for the conversion process, this will comprise data from processes that are either at the pioneer or commercial stage.

3. Additional Quantities in place/in situ (Category F4)

84. Category F4 may be utilized by Evaluators where there is an identifiable biomass resource in place, but a *Project* to extract the *Energy Product* has not been defined.

4. Availability of Biomass

85. While the contractual terms under which biomass is secured is a consideration for the E axis, and uncertainty surrounding quantity of biomass available is a consideration for the G axis, Evaluators should consider the quantities of biomass available in the proximity of the *Project* and/or the technical feasibility of the supply chain to deliver biomass within the F axis classification.

Table 4
Definitions and Use of F axis Categories and Sub-categories

Category	*Definition*	*Supporting Explanation (UNFC-2009, Part 1, Annex I)*	*Additional Bioenergy Context*
F1	*Feasibility of extraction by a defined development Project or mining operation has been confirmed.*	*Extraction is currently taking place or, implementation of the development Project or mining operation is underway; or, sufficiently detailed studies have been completed to demonstrate the feasibility of extraction by implementing a defined development Project or mining operation.*	*Bioenergy Source* and conversion technology shall be assessed as commercially available. For an F1 categorization, (1) the Biomass Source shall be available and commercially accessible to the *Project*, or alternatively meets the requirements set out in Part III Section B 2 for Multiple-Year Large Plots, or Currently Intercropped Species, or Historical Plot Data in Location; (2) the conversion technology shall be at the Pioneer or commercially available stage of technical maturity; (3) the feasibility of physically transporting the *Energy Product* to Market has been established; and (4) the sponsor has sanctioned the *Project* to one of the levels described below: • The *Project* is in commercial operation; the *Bioenergy Source* is being accessed, the conversion plant is operational, and the infrastructure is in place to deliver the *Energy Product(s)* to the relevant markets, or; • Capital funds have been committed for all elements of the *Project* and implementation is underway, or; • Sufficiently detailed studies have been completed to demonstrate the feasibility of all elements of the *Project* by implementing a defined development plan, and there are no reasons for the project not to proceed as per the planned schedule. Where the feasibility/maturity status varies across a *Project*, the lowest status shall define the categorization. Sub-categories may be utilized to reflect the level of sanction by the *Project* sponsor. An estimate for the F1 category and/or its sub-category shall be based on established operational data both for the *Bioenergy Source* and the conversion process(es) (see Part III Section B 2).
Sub-category	*Definition (UNFC-2009, Part 1, Annex II)*		*Additional Bioenergy Context*
F1.1	*Extraction is currently taking place.*		*Project* is in commercial operation and production of the *Energy Product* is taking place.
F1.2	*Capital funds have been committed and implementation of the development Project or mining operation is underway.*		Capital funds have been committed for all elements of the *Project* and implementation is underway.
F1.3	*Sufficiently detailed studies have been completed to demonstrate the feasibility of extraction by implementing a defined development Project or mining operation.*		Sufficiently detailed studies have been completed to demonstrate the feasibility of all elements of the *Project* by implementing a defined development plan(s), and there are no reasons for the project not to proceed as per the planned schedule.

Category	*Definition*	*Supporting Explanation (UNFC-2009, Part 1, Annex I)*	*Additional Bioenergy Context*
F2	*Feasibility of extraction by a defined development Project or mining operation is subject to further evaluation.*	*Preliminary studies demonstrate the existence of a deposit in such form, quality, and quantity that the feasibility of extraction by a defined (at least in broad terms) development Project or mining operation can be evaluated. Further data acquisition and/or studies may be required to confirm the feasibility of extraction.*	For a F2 categorization, both the *Bioenergy Source* and the conversion asset(s) that convert the *Bioenergy Source* into *Energy Products* shall at least meet the F2 criteria. Primarily, this means that for the *Bioenergy Source*, the technical maturity is at least at the Single-Year Large Plots, or Multiple-Year Small Plot stage, or is based on currently cropped related species data. For the conversion asset, this means the technology is at least at the pilot or demonstration Scale. In addition, there shall be a well-defined development plan that covers both the access of the *Bioenergy Source*, the development of the conversion asset, and the subsequent physical delivery of the *Energy Products* and any non-energy products to their associated markets.
Sub-category	*Definition (UNFC-2009, Part 1, Annex II)*		*Additional Bioenergy Context*
F2.1	*Project activities are ongoing to justify development in the Foreseeable Future.*		*Project's* development is pending: • The maturity of the *Bioenergy Source* at least meets the F2 requirements. • Conversion technology is at the demonstration Scale or a sufficiently large pilot Scale such that a demonstration-scale facility will not be required prior to the sanction of the pioneer or commercial-scale facility. • Access to commercially viable quantities of biomass (*Bioenergy Source*), and operation of the pioneer-scale facility is anticipated to occur within the *Foreseeable Future*. • Infrastructure to transport *Energy Products* to market is either existing or anticipated to occur within the *Foreseeable Future*.
F2.2	*Project activities are on hold and/or where justification as a commercial development may be subject to significant delay.*		*Project's* development is on hold or a significant time period is anticipated prior to commercial deployment. • The maturity of the *Bioenergy Source* at least meets the F2 requirements. • Conversion technology is at the pilot scale, and preliminary results indicate that the technology will be feasible at the pioneer or commercial scale. • Access to commercially viable quantities of biomass (Bioenergy source) and/or operation of the pioneer- or commercial-scale facility is not anticipated to occur within the *Foreseeable Future*.

Sub-category	*Definition (UNFC 2009, Part 1, Annex II)*	*Additional Bioenergy Context*
F2.3	*There are no current plans to develop or to acquire additional data at the time due to limited potential*	*Project's* development is on hold due to limited potential. • The maturity of the *Bioenergy Source* at least meets the F2 requirements. • Conversion technology is at the pilot scale. • Evaluation work on either the biomass source and/or on the conversion technology has been suspended.

Category	*Definition*	*Supporting Explanation (UNFC-2009, Part 1, Annex I)*	*Additional Bioenergy Context*
F3	*Feasibility of extraction by a defined development Project or mining operation cannot be evaluated due to limited technical data*	*Very preliminary studies (e.g., during the exploration phase), which may be based on a defined (at least in conceptual terms) development Project or mining operation, indicate the need for further data acquisition in order to confirm the existence of a deposit in such form, quality and quantity that the feasibility of extraction can be evaluated*	*Project's* development is pending: • *Bioenergy Source* has been identified, and its technical maturity at least meets F3 requirements • Conversion technology is at the Laboratory Scale or small Pilot Scale such that further data can be generated to establish the potential of the technology.

In some situations, it may be helpful to subclassify Exploratory Projects on the basis of their level of maturity. In such cases, the following specification shall apply:

Sub-category	*Definition (UNFC-2009, Part 1, Annex II)*	*Additional Bioenergy Context*
		The application of F3 sub-categories to Bioenergy *Exploratory Projects* shall be based on the degree of specificity regarding the location of the *Project*, given the dependence in most cases of the *Bioenergy Resource* on a location's characteristics. In all cases the specific *Bioenergy Source* shall be known or identified.
F3.1	*Where site-specific geological studies and exploration activities have identified the potential for an individual deposit with sufficient confidence to warrant drilling or testing that is designed to confirm*	The specific location of the *Project* is identified in terms of the land area from which the *Bioenergy Source* will be supplied. Location specific agronomic or other data relevant to the quantities of the *Bioenergy Source* is available.

	the existence of that deposit in such form, quality and quantity that the feasibility of extraction can be evaluated	

Sub-category	*Definition (UNFC-2009, Part 1, Annex II)*	*Additional Bioenergy Context*
F3.2	*Where local geological studies and exploration activities indicate the potential for one or more deposits in a specific part of a geological province, but requires more data acquisition and/or evaluation in order to have sufficient confidence to warrant drilling or testing that is designed to confirm the existence of a deposit in such form, quality and quantity that the feasibility of extraction can be evaluated.*	The *Project* location and/or land area from which the *Bioenergy Source* will be supplied is known or specified to an agricultural, or a forestry supply area, or another supply area relevant to the *Bioenergy Source* in question. This supply area shall be commonly accepted as having homogeneous characteristics for the *Bioenergy Source* in question. Area specific agronomic or other data relevant to the quantities of the *Bioenergy Source* is available.
F3.3	*At the earliest stage of exploration activities, where favourable conditions for the potential discovery of deposits in a geological province may be inferred from regional geological studies.*	The *Project* location and/or land area from which the *Bioenergy Source* will be supplied is only known or specified to a regional or country level. Only regional or country-level agronomic or other data relevant to the quantities of the *Bioenergy Source* is available.

Category	*Definition*	*Supporting Explanation (UNFC-2009, Part 1, Annex I)*	*Additional Bioenergy Context*	
F4	*No development Project or mining operation has been identified.*	*In situ (in-place) quantities that will not be extracted by any currently defined development Project or mining operation*	*Additional Renewable Energy Context*	**Category F4 can be used to classify the currently non-extractable quantities at the geographical location of the defined *Project* due to, for example, site/area constraints, technology limitations, and/or other constraints.**
			Additional Bioenergy Context	*Bioenergy Source* has been identified; however, there is either: (1) No defined or identified *Project* that will extract or convert the *Bioenergy Source* into quantities of Energy Products, or (2) There are quantities of energy products that are currently not feasible to recover from the *Bioenergy Source* but may become feasible to recover at a future date.

In some situations, it may be helpful to sub-classify Additional Quantities in Place on the basis of the current state of technological developments. In such cases, the following specification shall apply:

Sub-category	*Definition (UNFC-2009, Part 1, Annex II)*	*Additional Bioenergy Context*
		The F4 sub-category assessment shall consider both the technological maturity of both the *Bioenergy Source* (e.g., the biomass) and any conversion process(es) required for the subsequent conversion to *Energy Products*. The classification shall be based on the lowest level of technological maturity. It is emphasized that in the F4 classification the *Project* has still to be identified. Once a *Project* is identified, it is possible for the same level of technology maturity to be classified as F3.
F4.1	*The technology necessary to recover some or all of these quantities is currently under active development, following successful pilot studies on other deposits, but has yet to be demonstrated to be technically feasible for the style and nature of deposit in which that commodity or product type is located.*	See Part III Section B 2. For an F4.1 classification, the *Bioenergy Source* shall at least be at the greenhouse, or small plot development stage, or data is available based on the performance of surrogate species. The maturity of the conversion technology shall at least be at laboratory-scale.
F4.2	*The technology necessary to recover some or all of these quantities is currently being researched, but no successful pilot studies have yet been completed.*	See Part III Section B 2. For an F4.2 classification, the *Bioenergy Source* shall at least be in the greenhouse, or small plot development stage or data is available based on the performance of surrogate species. The maturity of the conversion technology shall at least be at the concept process engineering stage.
F4.3	*The technology necessary to recover some or all of these quantities is not currently under research or development.*	Neither the technologies required either to access the *Bioenergy Source* and/or to subsequently convert it to *Energy Products* are currently under development.

C. G-axis Categories

86. In UNFC-2009, the G axis designates the level of confidence in the geological knowledge and potential recoverability of the quantities. This definition reflects the fact that, at the time of its publication, UNFC-2009 was designed to be applied to fossil energy and mineral reserves and resources. It is recognized that the reference to geological knowledge is not applicable to *Bioenergy Resources*. Therefore, when applied to *Bioenergy Resources*, the G axis should be understood to reflect the ***level of confidence in the potential recoverability of the quantities.***

87. Thus, the G-axis categories are intended to reflect all significant uncertainties impacting the estimated *Bioenergy Resources* quantities that are forecast to be produced by the ***Project***. Uncertainties include both variability in the *Bioenergy Source* and the efficiency of the extraction and conversion methodology, and would typically include the following aspects:

(a) The biomass yield (e.g., tonnes/hectare), or another relevant *Bioenergy Source* recoverability parameter;

(b) Biomass physical properties that have implications for the subsequent conversion of the *Bioenergy Source* to *Energy Products* (e.g., sugar content, moisture content);

(c) Losses due to storage, or on transport prior to conversion to *Energy Products*;

(d) The uncertainty related to the access (contractual or otherwise) to the *Bioenergy Source*;

(e) The conversion yield of the *Bioenergy Source* to *Energy Products*;

(f) The throughput or processing rate of the conversion process(es);

(g) The technical lifetime of the conversion asset(s) within a defined maintenance program;

(h) Uncertainties relevant to the monetization of the *Energy Products*.

88. Specifically in regard to *Projects* that secure access to their *Bioenergy Source* by purchase agreements, the price and/or margin uncertainty and the associated implications for *Project* throughputs or processing rates shall be considered within the G axis. For example a *Project* obtaining its *Bioenergy Source* via purchase agreements that exists within a market or sector that has a track record of lower utilisation rates/economic run cuts due to low or negative margins will need to ensure that this is appropriately considered in the assessment. This assessment can be based either on historic data and/or on future market assessments (see Part II Section D.).

89. In general, an uncertainty impacts the quantity of *Bioenergy Resource* recovered from a *Project*, but not the viability of the *Project* itself. If the impact of an uncertainty is sufficient to affect the viability of the *Project*, then it should be considered to be a risk. In these circumstances, it may be appropriate to consider the impact of the uncertainty as a separate *Project* with a lower degree of maturity on either the E axis or F axis. This is of specific relevance in the assessment of the implications of possible future changes to any regulatory support that may impact the economic viability of the *Project*.

1. Considerations for Confidence Level (G1, G2 and G3)

90. Within UNFC-2009, there are three established approaches to determining appropriate estimates for G1, G2 and G3; two of which are based on the assessment of a range of uncertainty for quantities associated with a *Project* and the other reflecting different levels of confidence. The terms used within these specifications are as follows:

(a) The "incremental" approach, which is based on estimates for discrete portions of the *Bioenergy Source* and/or the *Project*, where each estimate is assigned on the basis of its level of confidence (high, moderate and low), reflecting available knowledge regarding potential recoverability;

(b) The "scenario" approach, which is based on three discrete scenarios that are designed to reflect the range of uncertainty in the possible outcomes (low, best, and high estimates) of the *Project* extracting energy from the *Bioenergy Source* as a whole;

(c) The "probabilistic" approach, where multiple possible scenarios are generated (e.g., by Monte Carlo analysis) from input distributions of parameter uncertainty associated with the *Project* extracting energy from the *Bioenergy Source* as a whole. Three specific outcomes are then selected from the output probability distribution as representative of the range of uncertainty (P90, P50 and P10 values are equated to low, best and high estimates respectively, where P90 means there is 90% probability of exceeding that quantity).

91. Any of the three approaches is permissible under the Bioenergy Specification. The assessment shall state which approach is being used; however, it is anticipated that the "scenario" or "probabilistic" approaches will be the most relevant.

92. Where the "scenario" or "probabilistic" approaches are used, the low (or P90) estimate is classified as G1, the best (or P50) estimate is classified as G1+G2, and the high (or P10) estimate is classified as G1+G2+G3.

93. In all cases, due consideration shall be given to possible dependencies between input parameters. Further, whichever approach is used, all three categories (G1, G2 and G3) should be reported to provide an indication of the range of uncertainty in the estimate.

94. Irrespective of the approach, the basis of the uncertainty assessment and/or assumptions shall be provided.

95. Where a *Project's* long-term financial or operating plan is being used to provide an estimate of a *Project's Bioenergy Resources*, then that plan/projection shall typically be considered as a best (or P50) estimate, that is, a G1+G2 classification.

2. Known versus Potential *Bioenergy Resources* (Category G4)

96. A known *Bioenergy Source*/resource is one where the source and subsequent resource estimate is based on primarily direct evidence. This includes both the *Bioenergy Source* (e.g., the availabilities of the biomass) and the subsequent conversion into *Energy Products*. Table 5 presents those estimates that shall be considered to form direct evidence. It is emphasized that the estimate for the *Bioenergy Source* and the subsequent conversion into *Energy Products* shall both be considered as direct evidence for the combined assessment to be considered as a Known Resource.

Table 5
Estimates that shall be considered to form direct evidence

Estimate Type	*Brief Description*
Biomass Availabilities	
Commercially established bioenergy crops data	Yield and other performance data obtained for the bioenergy crop that is relevant for the location in question established over a suitable number of cropping cycles. For annual crops, this should typically be considered as at least three years or harvests. For perennial and semi-perennial crops, this should typically be considered as at least two cropping cycles.
Data from Commercially established non-crop biomass recovery data.	Recovery data obtained for non-crop *Bioenergy Sources* (e.g., the bio-fraction of municipal solid waste) from established commercial recovery operations.
Data from commercially established intercropped crop.	Yield and other performance data obtained for bioenergy crops not currently grown at the location in question, but where there is yield/performance data for a species that is typically grown as an intercrop in the region that enables a reasonable estimate for yield and performance data to be made (e.g., soybean yields based on corn yields in the U.S. Midwest).
Large plot trial data [15]	Yield and other performance data obtained from large plot trials, both for single and multiple years and from single or multiple locations. Suitable adjustment should be made to account for yield differences when projecting to real world/commercial scale conditions.
Small plot or strip trial data[1]	Yield and other performance data obtained from small plot and/or strip trials. Suitable adjustment should be made to account for yield differences when projecting to real world/commercial-scale conditions.
Non-crop recovery trial data.	Recovery data obtained for non-crop *Bioenergy Sources* (e.g., the bio-fraction of Municipal Solid Waste) based on pre-commercial recovery trials. Suitable adjustment should be made to account for differences when projecting to real world/commercial-scale conditions.
Greenhouse data	Yield and other performance data obtained from greenhouse growing trials for the bioenergy crop in question. Suitable adjustment should be made to account for yield differences when projecting to real world/commercial-scale conditions.
Conversion to *Energy Products*	
Data from an existing *Project*	Operational performance data from the *Project* in question or from a similar *Project*.
Indicative or Guaranteed Performance Data	Projected operational performance data provided by a technology provider/licensor for established processes where there is an example operating at commercial scale.
Pilot/Demonstration Plant Data	Operational performance data obtained from a pilot- or demonstration-scale plant. Suitable adjustment should be made to account for performance

[15] See Part III Section B: F axis for clarifications on the distinction between Large and Small/Strip Trials and the appropriate F axis *categorisation*.

Estimate Type	*Brief Description*
	differences when technology deployed at commercial scale.
Engineering Study/ Process Simulation on established technologies	Operational performance data established from engineering studies and/or process simulation on established mature technologies where there are examples operating at commercial scale.

97. A Potential *Bioenergy Source* is one where the existence of a significant quantity of recoverable bioenergy has not yet been demonstrated by direct evidence but is assessed as potentially existing based primarily on indirect evidence. Table 6 sets out those estimates that typically could be considered to form indirect evidence.

Table 6
Estimates that typically could be considered to form indirect evidence

Estimate Type	*Brief Description*
Biomass Availabilities	
Data from currently cropped related species crops.	Yield and other performance data estimates interpolated from performance data of a related species for the location in question (e.g., camelina data based on canola data).
Large plot trials of surrogate species[15]	Yield and other performance data estimates interpolated from performance data from large plot trials of a suitable related surrogate species.
Small plot trials of surrogate species[15]	Yield and other performance data estimates interpolated from performance data from small plot trials of a suitable related surrogate species.
Greenhouse data from surrogate species	Yield and other performance data estimates interpolated from performance data from greenhouse plot trials of a suitable related surrogate species.
Yield Modelling	Yield modelling (yield maps) based on crop trial data interpolated for location-specific soil, water and other parameters for new previously uncommercialized crops. This can also include crops that are already commercially deployed in some regions but are yet to be commercially deployed in the region in question where adequate location-specific crop trials are yet to be completed. Regional long-term biomass availability studies, such as the U.S. DOE Billion Ton Study[16] shall typically be considered to fall in this category.
Conversion to *Energy Products*	
Operational performance estimates based on laboratory scale or theoretical studies.	Performance data for conversion technology that is yet to be deployed at pilot/demonstration plant scale.

[16] (2016) *The 2016 Billion-Ton Report: Advancing Domestic Resources for a Thriving Bioeconomy, Volume 1*, Oak Ridge National Laboratory on behalf of the United States Department of Energy (DOE).

98. Estimated *Bioenergy Sources* associated with Potential *Bioenergy Sources* shall be classified and reported using the G category G4 or its sub-categories G4.1, G4.2, and G4.3.

3. Expansion of G4 to account for uncertainty

99. In some situations, it may be helpful to express a range of uncertainty for quantities that are classified on the G4 axis, e.g., Potential Resources. In such cases, the following specification shall apply:

(a) G4.1: low or P90 estimate of the quantities;

(b) G4.2: incremental amount to G4.1 such that G4.1+G4.2 equates to a best or P50 estimate of the quantities;

(c) G4.3: incremental amount to G4.1+G4.2 such that G4.1+G4.2+G4.3 equates to a high or P10 estimate of the quantities.

100. Category G4, when used alone, shall reflect the best estimate and is equal to G4.1+G4.2.

Table 7

Definition of G-Axis Categories and Sub-Categories with supporting explanations

Category	*Definition*	*Supporting Explanation (UNFC-2009, Part I, Annex I)*	*Additional Renewable Energy Context*	*Additional Bioenergy Context*
G1	*Quantities associated with a known deposit that can be estimated with a high level of confidence.*	*For in situ (in place) quantities, and for recoverable estimates of fossil energy and mineral resources that are extracted as solids, quantities are typically categorized discretely, where each discrete estimate reflects the level of geological knowledge and confidence associated with a specific part of the deposit. The estimates are categorised as G1, G2 and/or G3 as appropriate.* *For recoverable estimates of fossil energy and mineral resources that are extracted as fluids, their mobile nature generally precludes assigning recoverable quantities to discrete parts of an accumulation. Recoverable quantities should be evaluated on the basis of the impact of the development scheme on the accumulation as a whole and are usually categorised on the basis of three scenarios or outcomes that are equivalent to G1, G1+G2 and G1+G2+G3.*	***The G axis reflects the level of confidence in the potential recoverability of the quantities. Thus, the G-axis categories are intended to reflect all significant uncertainties impacting the estimated Renewable Energy Resources quantities that are forecast to be extracted by the Project and typically would include (but not be limited to) areas such as metzorology, climatology, topography and other branches of geography, ecology and, for geothermal Projects, geology. Uncertainties include both variability in the Renewable Energy Source and the efficiency of the extraction and conversion methodology (where relevant). Typically, the various uncertainties will combine to provide a full range of possible outcomes, comparable to the extraction of fluids in the petroleum sector. In such cases, categorization should reflect three scenarios or outcomes that are equivalent to G1, G1+G2 and G1+G2+G3.***	The assessment of uncertainty shall consider the entirety of the *Project*, including variability associated with the *Bioenergy Source* and the subsequent conversion to *Energy Products*. In addition, the estimates for the *Bioenergy Source* and the subsequent conversion to *Energy Products* shall both be considered as direct evidence (see Table 5) for the combined assessment to be considered as a *Known Resource*, and hence qualify for a G1, G2, and/or G3 classification.
G2	*Quantities associated with a known deposit that can be estimated with a moderate level of confidence.*			
G3	*Quantities associated with a known deposit that can be estimated with a low level of confidence.*			

Category	*Definition*	*Supporting Explanation (UNFC-2009, Annex I)*	*Additional Renewable Energy Context*	*Additional Bioenergy Context*
G4	*Estimated quantities associated with a potential deposit, based primarily on indirect evidence.*	*Quantities that are estimated during the exploration phase are subject to a substantial range of uncertainty as well as a major risk that no development Project or mining operation may subsequently be implemented to extract the estimated quantities. Where a single estimate is provided, it should be the expected outcome but, where possible, a full range of uncertainty in the size of the potential deposit should be documented (e.g., in the form of a probability distribution). In addition, it is recommended that the chance (probability) that the potential deposit will become a deposit of any commercial significance is also documented.*	***Category G4 is equally applicable to renewable energy, for "Estimated quantities associated with a potential Renewable Energy Source, based primarily on indirect evidence" (e.g., mapping studies).***	The category G4 can be used to categorize Potential *Bioenergy Resources* and/or *Exploratory Projects*; that is, *Bioenergy Resources* that can only be estimated by the use of indirect evidence.

Sub-category	*Expansion of G4 to Account for Uncertainty*[17] *(UNFC-2009, Part II, Section VI, F)*	*Additional Bioenergy Context*
G4.1	*Low estimate of the quantities*	Refer to Part III Section C 3 for specifications on the use of the G4 sub-categories.
G4.2	*Incremental amount to G4.1 such that G4.1+G4.2 equates to a best estimate of the quantities.*	
G4.3	*Incremental amount to G4.1+G4.2 such that G4.1+G4.2+G4.3 equates to a high estimate of the quantities.*	

[17] Category G4, when used alone, shall reflect the best estimate and is equal to G4.1+G4.2

D. Adaptation of UNFC-2009 Classes and Sub-classes for *Bioenergy Projects*

101. As per UNFC-2009, there exists the provision to categorize a *Bioenergy Project* according to specific combinations of categories, defined as *classes* and *subclasses* as detailed below. More detailed specifications on the use of class and subclasses is detailed in UNFC-2009 Parts III & IV.

102. It is emphasized that the assessment for the total commodity initially in place is classified at a given defined date, which shall be referenced.

1. Classes

103. Table 8 shows UNFC-2009, in its abbreviated version with primary classes and categories, adapted for application to *Bioenergy Projects*. The adaption for Bioenergy maintains the same structure and definition as the abbreviated version of Figure 2 of UNFC-2009, but modifies some of the class descriptions to use terminology more suited for the Bioenergy Sector. For additional clarification, the associated footnotes to the UNFC-2009 Figure 2 are reproduced with similar terminological modifications.

Table 8

Abbreviated Version of UNFC 2009 adapted for *Bioenergy Projects*, showing Primary Classes

			Sales Production		
Produced			*Non-Sales Production*[a]		
		Class	*Categories*		
			E	*F*	*G*[b]
Total Commodity Initially in Place — Known Resources	Future recovery by currently commercial or sanctioned projects	Commercial Projects[c]	1	1	1, 2, 3
	Potential future recovery by contingent development projects	Potentially Commercial *Projects*[d]	2[e]	2	1, 2, 3
		Non-Commercial *Projects*[f]	3	2	1, 2, 3
	Additional quantities in place associated with a Known Resource[g]		3	4	1, 2, 3
Potential Resources	*Exploratory Project*		3	3	4
	Additional quantities in place associated with a Potential Resource[g]		3	4	4

[a] Future non-sales production is categorized as E3.1. Resources that will be produced but not sold can exist for all classes of recoverable quantities. They are not shown in the figure.

[b] G categories may be used discretely or in cumulative form (e.g. G1+G2), see Part III Section C.

[c] Commercial Projects have been confirmed to be technically, economically and socially feasible. Recoverable quantities associated with Commercial Projects are defined in many classification systems as Reserves, but there are some material differences between the specific definitions that are applied within the extractive industries and hence the term is not used here.

[d] Potentially Commercial Projects are expected to be developed in the *Foreseeable Future*, in that the quantities are assessed to have reasonable prospects for eventual economic production, but technical and/or commercial feasibility has not yet been confirmed. Consequently, not all Potentially Commercial Projects may be developed.

[e] Potentially Commercial Projects may satisfy the requirements for E1.

[f] Non-Commercial Projects include those that are at an early stage of evaluation in addition to those that are considered unlikely to become commercially feasible developments within the *Foreseeable Future*.

[g] A portion of these quantities may become recoverable in the future as technological developments occur. Depending on the commodity type and recovery technology (if any) that has already been applied, some or all of these quantities may never be recovered due to physical and/or chemical constraints. See Part III Sections B and C regarding the definitions and specifications related to application of F4 and G4 for *Bioenergy Projects*.

2. Sub-classes

104. As per UNFC-2009 Section IV, additional subclasses are defined based on the sub-categories included in Annex II. These are illustrated in Table 9.

Table 9

UNFC 2009 Classes and Subclasses defined by sub-categories adapted for Bioenergy Projects[a]

Total Commodity Initially in Place	*Produced*	Sales Production			
		Non-Sales Production			
	Class	*Sub-class*	*Categories*		
			E	*F*	*G*

Known Resource	Commercial *Projects*	On Production	1[c]	1.1	1, 2, 3
		Approved for Development	1[c]	1.2	1, 2, 3
		Justified for Development	1[c]	1.3	1, 2, 3
	Potentially Commercial *Projects*	Development Pending	2	2.1	1, 2, 3
		Development on Hold	2[b]	2.2	1, 2, 3
	Non-Commercial *Projects*	Development Unclarified	3.2	2.2	1, 2, 3
		Development Not Viable	3.3	2.3	1, 2, 3
	Additional quantities in place associated with a known Resource		3.3	4	1, 2, 3
Potential Resource	*Exploratory Project*	[No subclasses defined]	3.2	3	4
	Additional quantities in place associated with a potential Resource		3.3	4	4

[a] Refer also to notes for Table 8.

[b] Development Pending Projects may satisfy the requirements for E1.

[c] Subclasses E1.1 & E1.2 may be used if appropriate – see Part II Section A.7.

E. Estimation

105. The fact that the Bioenergy Sector consists of many energy pathways involving many types of biomass and conversion technologies precludes a prescriptive approach to estimation in this specification. Specifically, estimation approaches for the yield and other relevant parameters for the *Bioenergy Source* can vary not only by biomass type but also by regions dependent on various agronomic factors. However, as a general principle, Evaluators should use recognized methodologies and procedures and where available, follow standards relevant to the *Bioenergy Source* and conversion technology in the region/area concerned. The source or basis for any estimations shall be appropriately referenced in the evaluation. This includes not only third-party data but also methodologies or procedures that have been used by the evaluating entity to generate in-house data.

F. Evaluator Qualifications

106. Evaluators shall possess an appropriate level of expertise and relevant experience in the estimation of quantities associated with the type of *Bioenergy Resource(s)* under evaluation.[18] It is anticipated that the estimation of *Bioenergy Resources* will require the input from professionals and/or experts from several technical disciplines. The person or persons may be employees of the entities that have an economic interest in the project or independent consultants contracted for reviews and audits. In all cases, the entity accepting the evaluation takes responsibility for the results of the estimation. The relationship between the issuing entity and the evaluators shall be stated.

G. Avoidance of Double Counting

107. Given the wide range of bioenergy pathways and the complexity within some of those pathways, it is not possible to frame a definition of *Bioenergy Sources* and *Energy Products* that completely excludes the possibility of one entity carrying out a resource estimate on material that another entity or entities has/have already included in a separate resource estimate(s). This is particularly relevant, but not limited to, circumstances where the *Project* includes *Energy Products* not contained in the list of predefined *Energy Products* (See Part II Section A.2). Therefore, as part of any resource estimation made for the purposes of disclosure, an Evaluator and/or responsible entity shall make best endeavours to ensure that another entity or entities has/has not carried out a resource categorization and estimation on quantities of either *Bioenergy Sources* or *Energy Products* involved in *Project* under evaluation. This assurance can be made either via investigation or other determination of the bioenergy pathways concerned, and/or via contractual or legal agreement between concerned parties that determines the entity or entities that has/have the right to carry out a resource classification and, if the appropriate report, the resulting resource estimate.

108. If assurance of the avoidance of double counting cannot be made, then no resource classification or estimate shall be made on the quantities concerned.

H. Units and Conversion Factors

109. In order to facilitate global comparability of resource estimates, it is recommended that the Système International d'Unités (SI units) is used for reporting of resource quantities. However, it is recognized that there are traditional measurement units that are widely used and accepted for certain commodities; where such units are used for reporting purposes, conversion factors to SI units shall be provided. Similarly, where quantities are converted from volume or mass to energy equivalents, or other conversions are applied, the conversion factors shall be disclosed.

[18] Certain national or regional regulations may require or mandate specific qualifications, licences or expertise as part of the regulatory approval process.

Annex

Definition of Categories and Sub-categories

To assist definitions and to provide an overview, the definitions for the E, F and G axis categories and sub-categories (Tables 3, 4 and 7) are replicated below.

Category	*Definition*	*Supporting Explanation (UNFC-2009, Part I, Annex I)*	*Additional Bioenergy Context*	
			Criteria	*Requirements*
E1	*Extraction and sale has been confirmed to be economically viable.*	*Extraction and sale is economic on the basis of current market conditions and realistic assumptions of future market conditions. All necessary approvals contracts have been confirmed or there are reasonable expectations that all such approvals contracts will be obtained within a reasonable time frame. Economic viability is not affected by short-term adverse market conditions provided that longer-term forecasts remain positive.*	*Access and Entitlement*	Beneficial rights exist to access and exploit the *Bioenergy Source*, as well as rights to utilize a conversion process (via either an existing asset or an investment) to convert the *Bioenergy Source* into marketable *Energy Products*. The entity shall be exposed to risks and rewards associated with both the *Bioenergy Source* and the Conversion asset(s). A supply framework (see Part II Section D) for defined quantities of the *Bioenergy Source* for a determined time period is in place. If the supply framework is dependent on contractual agreements, these are signed and/or there are expectations that this will occur within a reasonable time frame. The time period for which rights exist should be defined; moreover, the contracts shall at least cover sufficient quantities to support the economic operation of the *Project*.
			Market and Sales Connectivity	Infrastructure with sufficient capacity to transport or otherwise transfer the production to the markets in question for sale either exists or is planned and approved for implementation. Any necessary off-take or sales agreements required to monetize the *Energy Products* and any associated non-*Energy Products* are in place, as evidenced by signed documents, for a determined time period or there are *Reasonable Expectations* that these will be secured within a *Reasonable Time Frame*. The *Project's Energy Product(s)* meet any relevant standards or specifications, and any necessary registration, approval, or qualification required for the *Energy Products* to be recognized under any relevant legislation is either in place, or there are *Reasonable Expectations* for this to occur within a *Reasonable Time Frame*.

Category	*Definition*	*Supporting Explanation (UNFC-2009, Part I, Annex I)*	*Additional Bioenergy Context*	
			Criteria	*Requirements*
			Authorization	All necessary regulatory and permitting approvals required by governments and/or relevant regulatory authorities are either in place, supported by documentary evidence for a defined time period, or are expected to be in place within a *Reasonable Time Frame*.
			Economic Case Validation	An economic case exists that demonstrates the *Project* is economically viable, either as a new investment or as an existing operation. Consistency exists between capital investment, operating costs, and the expected production profile and *Project* lifetime. Economic indications demonstrate positive cash flows over the determined lifetime of the *Project*.
			Social and Environmental Considerations	Any social and environmental contingencies have been resolved, or there are *Reasonable Expectations* for them to be resolved within a *Reasonable Time Frame*. The *Project* is not expected to be halted or its operations seriously impeded due to a lack of social licence to operate[19].

Sub-category	*Definition (UNFC-2009, Part I, Annex II)*	*Additional Bioenergy Context*
E1.1	*Extraction and sale is economic on the basis of current market conditions and realistic assumptions of future market condition.*	No additional carifications.
E1.2	*Extraction and sale is not economic on the basis of current market conditions and realistic assumptions of future market condition, but is made viable through government subsidies and/or other consideration.*	In addition to the overarching requirements for E1, the calculation of economic viability is dependent on regulatory support. This includes any regulatory support and/or grants or subsidies needed to make the current *Project* economically viable (see Part III Section A 6.3). If grants or subsidies were used in the past (e.g., to develop the technology or process) they are no longer relevant to the classification of the *Bioenergy Resource*.

[19] For further guidance refer to "Draft guidance on accommodating environmental and social considerations in the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009", April 2016

Category	*Definition*	*Supporting Explanation (UNFC-2009, Part I, Annex I)*	*Additional Bioenergy Context*	
			Criteria	*Requirements*
E2	*Extraction and sale is expected to become economically viable in the Foreseeable Future.*	*Extraction and sale has not yet been confirmed to be economic but, on the basis of realistic assumptions of future market conditions, there are reasonable prospects for economic extraction and sale in the Foreseeable Future*	*Access and Entitlement*	Beneficial rights exists to access and exploit the *Bioenergy Source*, as well as either rights to utilize an conversion process (via either an existing asset or an investment) to convert the *Bioenergy Source* into marketable *Energy Products*. A supply framework (see Part II Section D) for defined quantities of the *Bioenergy Source* for a determined time period is not yet in place, but there are expectations that this will occur within *the Foreseeable Future*.
			Market and Sales Connectivity	The market(s) for the sale of the *Energy Product(s)* have been identified, and there are robust estimates or assumptions for the likely prices. At least one potentially viable means of transport or transfer of the product(s) to the market(s) has been identified. There is sufficient evidence to expect that any necessary off-take or sales agreements required to monetize the *Energy Products* and any associated non-*Energy Products* will be forthcoming within the *Foreseeable Future*. There is sufficient evidence to expect that the *Project's Energy Product(s)* will meet any relevant standards or specifications, and any necessary registration or approval required the *Energy Products* to be recognized under any relevant legislation within a *Reasonable Time Frame*.
			Authorization	A development plan has been defined, and there is evidence to expect execution of all necessary regulatory and permitting approvals required by governments and/or relevant regulatory authorities within in the *Foreseeable Future*.
			Economic Case Validation	An economic case exists that demonstrates that the *Project* is economically viable on the basis of realistic assumptions of future market conditions. Consistency exists between capital investment, operating costs and the expected production profile and *Project* lifetime. Economic indications demonstrate positive cash flows over the determined lifetime of the *Project*.

Category	*Definition*	*Supporting Explanation (UNFC-2009, Part I, Annex I)*	*Additional Bioenergy Context*	
			Criteria	*Requirements*
			Social and Environmental Considerations	Social and environmental contingencies have been identified, and there is a defined plan to address and resolve those contingencies within the *Foreseeable Future*[20].
	No E2 sub-categories are defined.			

Category	*Definition*	*Supporting Explanation (UNFC-2009, Part I, Annex I)*	*Additional Bioenergy Context*	
E3	*Extraction and sale is not expected to become economically viable in the Foreseeable Future or evaluation is at too early a stage to determine economic viability.*	*On the basis of realistic assumptions of future market conditions, it is currently considered that there are no reasonable prospects for economic extraction and sale in the Foreseeable Future; or, economic viability of extraction cannot yet be determined due to insufficient information (e.g., during the assessment phase). Also included are quantities that are forecast to be converted, but which will not be available for sale.*	*Criteria*	*Requirements*
			Access and Entitlement	The *Bioenergy Source* has been identified, and a preliminary evaluation has occurred, but access has not been secured or confirmed. Likewise, a preliminary evaluation of the necessary conversion asset (existing or investment) has been made, but access is not secured or confirmed.
			Market and Sales Connectivity	Potential market(s) for the future sale of the *Energy Product(s)* and/or non-*Energy Products* have either not been identified or only indicative estimates on pricing and market volumes are available. There are plans for further evaluation to identify at least one commercially viable business case.
			Authorisation	Ability to obtain necessary governmental and/or regulatory approvals and permits is unknown or deemed unlikely to occur within the *Foreseeable Future*
			Economic Case Validation	The economic case/viability cannot be determined due to insufficient information; or, based on realistic assumptions of market conditions, the *Project* is not economically viable.
			Social and Environmental Considerations	Both social and environmental issues have not yet been identified or evaluated, or there are significant social and environmental contingencies that will halt or seriously impede the implementation of the *Project*, and there is either no clearly defined plan to resolve the issues, or resolution is unlikely to occur in the *Foreseeable*

[20] For further guidance refer to "Draft guidance on accommodating environmental and social considerations in the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009", April 2016

		Future.
Sub-category	*Definition (UNFC-2009, Part 1, Annex II)*	*Additional Bioenergy Context*
E3.1	*Quantities that are forecast to be extracted, but which will not be available for sale.*	This includes energy extracted from the *Bioenergy Source* that is used internally by the conversion process to produce the *Energy Products* (e.g., power and steam generation for on-site use); therefore, not available for sale.
E3.2	*Economic viability of extraction cannot yet be determined due to insufficient information (e.g., during the exploration phase).*	No additional clarifications.
E3.3	*On the basis of realistic assumptions of future market conditions, it is currently considered that there are not reasonable prospects for economic extraction and sale in the Foreseeable Future.*	No additional clarifications.

Category	*Definition*	*Supporting Explanation (UNFC-2009, Part I, Annex I)*	*Additional Bioenergy Context*
F1	*Feasibility of extraction by a defined development Project or mining operation has been confirmed.*	*Extraction is currently taking place or, implementation of the development Project or mining operation is underway, or, sufficiently detailed studies have been completed to demonstrate the feasibility of extraction by implementing a defined development Project or mining operation.*	*Bioenergy Source* and conversion technology shall be assessed as commercially available. For an F1 categorization, (1) the Biomass Source shall be available and commercially accessible to the *Project*, or alternatively meets the requirements set out in Part III Section B 2 for Multiple-Year Large Plots, or Currently Intercropped Species, or Historical Plot Data in Location; (2) the conversion technology shall be at the Pioneer or commercially available stage of technical maturity; (3) the feasibility of physically transporting the *Energy Product* to Market has been established; and (4) the sponsor has sanctioned the *Project* to one of the levels described below: • The *Project* is in commercial operation; the *Bioenergy Source* is being accessed, the conversion plant is operational, and the infrastructure is in place to deliver the *Energy Product(s)* to the relevant markets, or; • Capital funds have been committed for all elements of the *Project* and implementation is underway, or; • Sufficiently detailed studies have been completed to demonstrate the feasibility of all elements of the *Project* by implementing a defined development plan, and there are no reasons for the project not to proceed as per the planned schedule. • Where the feasibility/maturity status varies across a *Project*, the lowest status shall define the categorization. Sub-categories may be utilized to reflect the level of sanction by the *Project* sponsor. An estimate for the F1 category and/or its sub-category shall be based on established operational data both for the *Bioenergy Source* and the conversion process(es) (see Part III Section B 2).

Sub-category	*Definition (UNFC-2009, Part I, Annex II)*	*Additional Bioenergy Context*
F1.1	*Extraction is currently taking place.*	*Project* is in commercial operation and production of the *Energy Product* is taking place.
F1.2	*Capital funds have been committed and implementation of the development Project or mining operation is underway.*	Capital funds have been committed for all elements of the *Project* and implementation is underway.
F1.3	*Sufficiently detailed studies have been completed to demonstrate the feasibility of extraction by implementing a defined development Project or mining operation.*	Sufficiently detailed studies have been completed to demonstrate the feasibility of all elements of the *Project* by implementing a defined development plan(s), and there are no reasons for the project not to proceed as per the planned schedule.

Category	*Definition*	*Supporting Explanation (UNFC-2009, Part I, Annex I)*	*Additional Bioenergy Context*
F2	*Feasibility of extraction by a defined development Project or mining operation is subject to further evaluation.*	*Preliminary studies demonstrate the existence of a deposit in such form, quality, and quantity that the feasibility of extraction by a defined (at least in broad terms) development Project or mining operation can be evaluated. Further data acquisition and/or studies may be required to confirm the feasibility of extraction.*	For a F2 categorization, both the *Bioenergy Source* and the conversion asset(s) that convert the *Bioenergy Source* into *Energy Products* shall at least meet the F2 criteria. Primarily, this means that for the *Bioenergy Source*, the technical maturity is at least at the Single-Year Large Plots, or Multiple-Year Small Plot stage, or is based on currently cropped related species data. For the conversion asset, this means the technology is at least at the pilot or demonstration Scale. In addition, there shall be a well-defined development plan that covers both the access of the *Bioenergy Source*, the development of the conversion asset, and the subsequent physical delivery of the *Energy Products* and any non-energy products to their associated markets.

Sub-category	*Definition (UNFC-2009, Part I, Annex II)*	*Additional Bioenergy Context*
F2.1	*Project activities are ongoing to justify development in the Foreseeable Future.*	*Project's* development is pending: • The maturity of the *Bioenergy Source* at least meets the F2 requirements. • Conversion technology is at the demonstration Scale or a sufficiently large pilot Scale such that a demonstration-scale facility will not be required prior to the sanction of the pioneer or commercial-scale facility. • Access to commercially viable quantities of biomass (*Bioenergy Source*), and operation of the pioneer-scale facility is anticipated to occur within the *Foreseeable Future*. • Infrastructure to transport *Energy Products* to market is either existing or anticipated to occur within the *Foreseeable Future*.
F2.2	*Project activities are on hold and/or where justification as a commercial development may be subject to significant delay.*	*Project's* development is on hold or a significant time period is anticipated prior to commercial deployment. • The maturity of the *Bioenergy Source* at least meets the F2 requirements. • Conversion technology is at the pilot scale, and preliminary results indicate that the technology will be feasible at the pioneer or commercial scale. • Access to commercially viable quantities of biomass (Bioenergy source) and/or operation of the pioneer- or commercial-scale facility is not anticipated to occur within the *Foreseeable Future*.

Sub-category	*Definition (UNFC-2009, Part 1, Annex II)*		*Additional Bioenergy Context*
F2.3	*There are no current plans to develop or to acquire additional data at the time due to limited potential.*		*Project's* development is on hold due to limited potential. • The maturity of the *Bioenergy Source* at least meets the F2 requirements. • Conversion technology is at the pilot scale. • Evaluation work on either the biomass source and/or on the conversion technology has been suspended.
Category	*Definition*	*Supporting Explanation (UNFC-2009, Part I, Annex I)*	*Additional Bioenergy Context*
F3	*Feasibility of extraction by a defined development Project or mining operation cannot be evaluated due to limited technical data.*	*Very preliminary studies (e.g., during the exploration phase), which may be based on a defined (at least in conceptual terms) development Project or mining operation, indicate the need for further data acquisition in order to confirm the existence of a deposit in such form, quality and quantity that the feasibility of extraction can be evaluated*	*Project's* development is pending: • *Bioenergy Source* has been identified, and its technical maturity at least meets F3 requirements • Conversion technology is at the Laboratory Scale or small Pilot Scale such that further data can be generated to establish the potential of the technology.

In some situations, it may be helpful to subclassify Exploratory Projects on the basis of their level of maturity. In such cases, the following specification shall apply:

Sub-category	Definition (UNFC-2009, Table 2, Annex II)	Taxonomy Bioenergy Criteria
		The application of F3 sub-categories to Bioenergy *Exploratory Projects* shall be based on the degree of specificity regarding the location of the *Project*, given the dependence in most cases of the *Bioenergy Resource* on a location's characteristics. In all cases, the specific *Bioenergy Source* shall be known or identified.
F3.1	*Where site-specific geological studies and exploration activities have identified the potential for an individual deposit with sufficient confidence to warrant drilling or testing that is designed to confirm the existence of that deposit in such form, quality and quantity that the feasibility of extraction can be evaluated.*	The specific location of the *Project* is identified in terms of the land area from which the *Bioenergy Source* will be supplied. Location specific agronomic or other data relevant to the quantities of the *Bioenergy Source* is available.
F3.2	*Where local geological studies and exploration activities indicate the potential for one or more deposits in a specific part of a geological province, but requires more data acquisition and or evaluation in order to have sufficient confidence to warrant drilling or testing that is designed to confirm the existence of a deposit in such form, quality and quantity that the feasibility of extraction can be evaluated.*	The *Project* location and/or land area from which the *Bioenergy Source* will be supplied is known or specified to an agricultural, or a forestry supply area, or another supply area relevant to the *Bioenergy Source* in question. This supply area shall be commonly accepted as having homogeneous characteristics for the *Bioenergy Source* in question. Area specific agronomic or other data relevant to the quantities of the *Bioenergy Source* is available.
F3.3	*At the earliest stage of exploration activities, where favourable conditions for the potential discovery of deposits in a geological province may be inferred from regional geological studies.*	The *Project* location and/or land area from which the *Bioenergy Source* will be supplied is only known or specified to a regional or country level. Only regional or country-level agronomic or other data relevant to the quantities of the *Bioenergy Source* is available.

Category	Definition	Supporting Explanation (CRIRSCO - 2006: Part 1: Annex 1)		
F4	No development Project or mining operation has been identified.	In situ (in place) quantities that will not be extracted by any currently defined development Project or mining operation.	Additional Renewable Energy Context	**Category F4 can be used to classify the currently non-extractable quantities at the geographical location of the defined *Project* due to, for example, site/area constraints, technology limitations, and/or other constraints.**
			Additional Bioenergy Context	*Bioenergy Source* has been identified; however, there is either: (1) No defined or identified *Project* that will extract or convert the *Bioenergy Source* into quantities of Energy Products, or (2) There are quantities of energy products that are currently not feasible to recover from the *Bioenergy Source* but may become feasible to recover at a future date.

In some situations, it may be helpful to sub-classify Additional Quantities in Place on the basis of the current state of technological developments. In such cases, the following specification shall apply:

Sub-category	Definition (CRIRSCO - 2006: Part 1: Annex 1)	Additional Bioenergy Context
		The F4 sub-category assessment shall consider both the technological maturity of both the *Bioenergy Source* (e.g., the biomass) and any conversion process(es) required for the subsequent conversion to *Energy Products*. The classification shall be based on the lowest level of technological maturity. It is emphasized that in the F4 classification the *Project* has still to be identified. Once a *Project* is identified, it is possible for the same level of technology maturity to be classified as F3.
F4.1	The technology necessary to recover some or all of these quantities is currently under active development, following successful pilot studies on other deposits, but has yet to be demonstrated to be technically feasible for the style and nature of deposit in which that commodity or product type is located.	See Part III Section B.2. For an F4.1 classification, the *Bioenergy Source* shall at least be in the greenhouse, or small plot development stage or data is available based on the performance of surrogate species. The maturity of the conversion technology shall at least be at laboratory-scale.
F4.2	The technology necessary to recover some or all of these quantities is currently being researched, but no successful pilot studies have yet been completed.	See Part III Section B.2. For an F4.2 classification, the *Bioenergy Source* shall at least be in the greenhouse, or small plot development stage, or data is available based on the performance of surrogate species. The maturity of the conversion technology shall at least be at the concept process engineering stage.
F4.3	The technology necessary to recover some or all of these quantities is not currently under research or development.	Neither the technologies required either to access the *Bioenergy Source* and/or to subsequently convert it to *Energy Products* are currently under development.

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Category	Definition	Supporting Explanation (UNFC-2009, Part I, Annex I)	Additional Renewable Energy Context	Additional Bioenergy Energy Context
G1	*Quantities associated with a known deposit that can be estimated with a high level of confidence.*	*For in situ (in place) quantities, and for recoverable estimates of fossil energy and mineral resources that are extracted as solids, quantities are typically categorised discretely, where each discrete estimate reflects the level of geological knowledge and confidence associated with a specific part of the deposit. The estimates are categorised as G1, G2 and or G3 as appropriate.* *For recoverable estimates of fossil energy and mineral resources that are extracted as fluids, their mobile nature generally precludes assigning recoverable quantities to discrete parts of an accumulation. Recoverable quantities should be evaluated on the basis of the impact of the development scheme on the accumulation as a whole and are usually categorised on the basis of three scenarios or outcomes that are equivalent to G1, G1+G2 and G1+G2+G3.*	***The G axis reflects the level of confidence in the potential recoverability of the quantities. Thus, the G axis categories are intended to reflect all significant uncertainties impacting the estimated Renewable Energy Resources quantities that are forecast to be extracted by the Project and typically would include (but not be limited to) areas such as meteorology, climatology, topography and other branches of geography, ecology and, for geothermal Projects, geology. Uncertainties include both variability in the Renewable Energy Source and the efficiency of the extraction and conversion methodology (where relevant).*** ***Typically, the various uncertainties will combine to provide a full range of possible outcomes, comparable to the extraction of fluids in the petroleum sector. In such cases, categorization should reflect three scenarios or outcomes that are equivalent to G1, G1+G2 and G1+G2+G3.***	The assessment of uncertainty shall consider the entirety of the *Project*, including variability associated with the *Bioenergy Source* and the subsequent conversion to *Energy Products*. In addition, the estimates for the *Bioenergy Source* and the subsequent conversion to *Energy Products* shall both be considered as direct evidence (see Table 5) for the combined assessment to be considered as a *Known Resource*, and hence qualify for a G1, G2, and/or G3 classification.
G2	*Quantities associated with a known deposit that can be estimated with a moderate level of confidence.*			
G3	*Quantities associated with a known deposit that can be estimated with a low level of confidence.*			

Category	Definition	Supporting Explanation (UNFC-2009, Part I, Annex I)	Additional Renewable Energy Context	Additional Bioenergy Energy Context
G4	*Estimated quantities associated with a potential deposit, based primarily on indirect evidence.*	*Quantities that are estimated during the exploration phase are subject to a substantial range of uncertainty as well as a major risk that no development Project or mining operation may subsequently be implemented to extract the estimated quantities. Where a single estimate is provided, it should be the expected outcome but, where possible, a full range of uncertainty in the size of the potential deposit should be documented (e.g., in the form of a probability distribution). In addition, it is recommended that the chance (probability) that the potential deposit will become a deposit of any commercial significance is also documented.*	***Category G4 is equally applicable to renewable energy, for "Estimated quantities associated with a potential Renewable Energy Source, based primarily on indirect evidence" (e.g. mapping studies).***	The category G4 can be used to categorize Potential *Bioenergy Resources* and/or *Exploratory Projects*, that is, *Bioenergy Resources* that can only be estimated by the use of indirect evidence.

Sub-category	Expansion of G4 to Account for Uncertainty[21] (UNFC-2009, Part II, Section VI, P)	Additional Bioenergy Energy Context
G4.1	*Low estimate of the quantities*	Refer to Part III Section C 3 for spefications on the use of the G4 sub-categories.
G4.2	*Incremental amount to G4.1 such that G4.1+G4.2 equates to a best estimate of the quantities*	
G4.3	*Incremental amount to G4.1+G4.2 such that G4.1+G4.2+G4.3 equates to a high estimate of the quantities*	

[21] Category G4, when used alone, shall reflect the best estimate and is equal to G4.1+G4.2.